Elegant Simplicity: The Late Gothic Plan Design of St.-Maclou in Rouen

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In memory of George H. Forsyth, Jr.

When the merchant families of the parish of St.-Maclou undertook the reconstruction of their church in the 1430s, they brought Pierre Robin, the former *sergent d'armes et maçon général* of Paris, to the English-occupied city of Rouen.[1] On May 12, 1437, Robin presented the treasurers with a complete drawing of the church and then disappeared from all local documentation. This drawing, no doubt, included a ground plan of the church that was scrupulously followed over the next fifty years until the entire church had been laid out and the nave vaults completed. Robin was granted the rare opportunity to design a church from foundation to spire, a task that drew on the cumulative knowledge of the Gothic building craft that had evolved over a period of three hundred years. Yet Robin's remarkable plan, from which space, mass, and structure were generated, introduced a number of novel features into Gothic church design that were to recur with great frequency in the parish churches of late fifteenth-century Normandy. The geometric underpinnings of the plan design are explicitly revealed in the presence of a polygonal porch, axial pier, polygonal interlocking radiating chapels, and unequal-size bays. These unorthodox features suggest that although Late Gothic monuments are visually complex, they may also be a more articulate expression of Gothic design and building practice (Fig. 1).[2] An examination of the relationship between the creative process of design on parchment and practical execution of the plan at the site provides a pragmatic explanation for these design features and permits us to reconsider some basic assumptions concerning Late Gothic architecture.

Within the formalist traditions of art history, Flamboyant architecture has generally been treated as the late or "declining" phase of Gothic style, and, because of a general consistency in decorative vocabulary, it was assumed to reflect a variety of foreign influences.[3] There have been few recent studies to dispel the notion that the form and meaning of fifteenth-century French architecture resides in something other than its decoration and writhing tracery patterns.[4] By focusing on the decorative vocabulary of the Late Gothic, Henri Focillon expressed the view that fifteenth-century architecture in France was "witness to great confusion of thought."[5] He pointed out that structure lost its significance and became a mere decorative effect under the lavish detail.

The international character of Late Gothic architecture was considered the result of a vague and loosely defined influence of one monument or group of monuments over another. Decorative features, such as double-curved tracery and ogees, were transmitted over distances through points of cultural contact, especially during the English occupation of Normandy in the first half of the fifteenth century.[6] Some scholars have pointed out that the polygonal porch and axial pier of St.-Maclou were inventions of German and Central European architects and were imported over long distances

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[1] An expanded discussion of Pierre Robin and the patrons of St.-Maclou will appear in my forthcoming book, *Disciplined Exuberance. Essays on the Parish Church of Saint-Maclou and Late Gothic Architecture in Rouen* (Pennsylvania State Press).

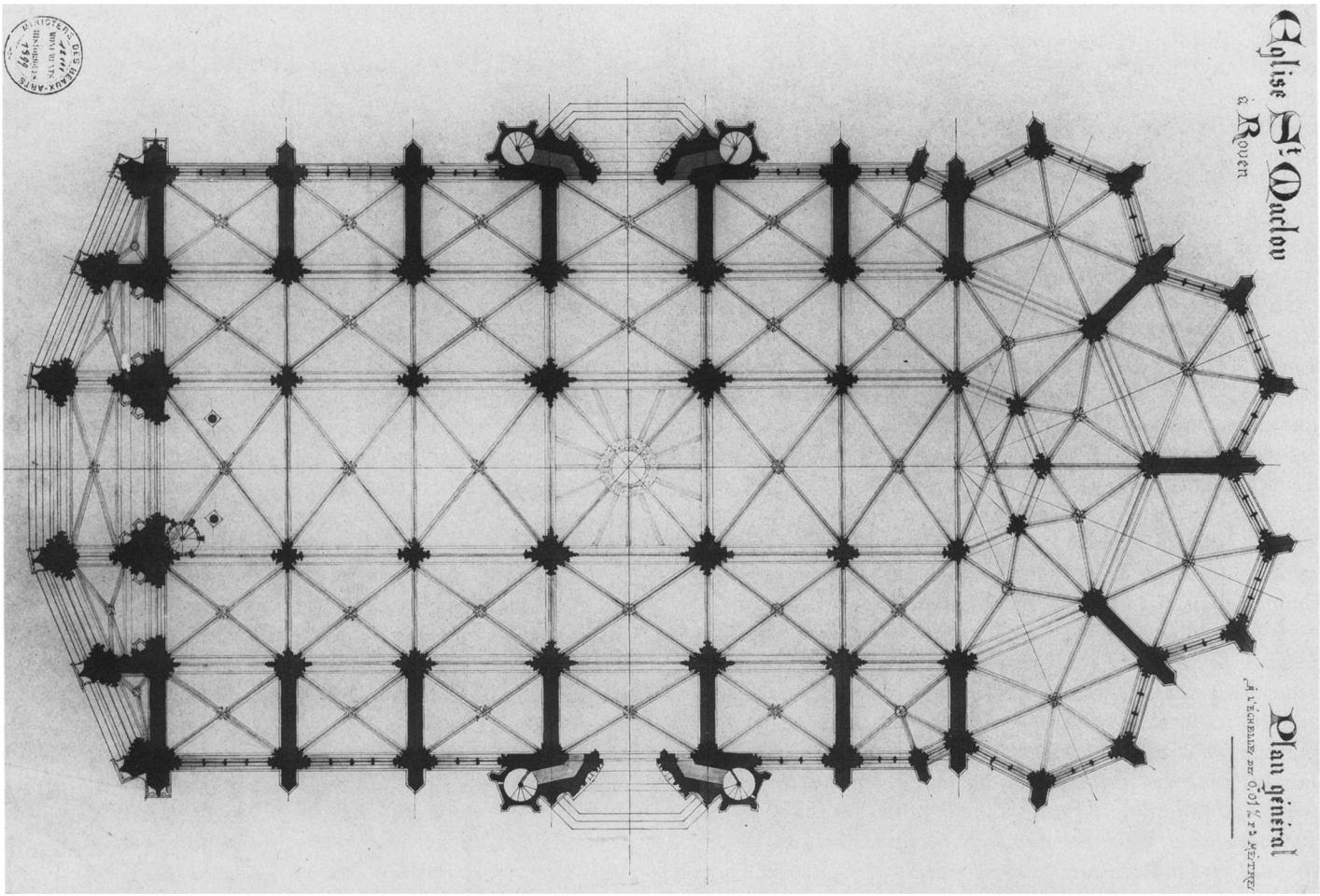
[2] These features appear in numerous churches in Normandy dating to the second half of the fifteenth century. The axial pier is found at Notre-Dame at Caudebec-en-Caux (choir 1450–87), St.-Pierre at Caen (choir 1479–1510), St.-Germain at Argentan (choir completed 1602), and St.-Paul at Le Neubourg (ca. 1500). The polygonal porch in a variety of forms was used at St.-Vincent at Rouen (begun 1480), Notre-Dame at Alençon (begun 1477), St.-Germain at Argentan (ca. 1480), La Trinité at Falaise (late 15th century), and Notre-Dame at Louviers (ca. 1510). Interlooking hexagonal chapels are also found in Normandy at Caen and Caudebec-en-Caux and are characteristic of Late Gothic plans in other regions, such as La Madeleine in Troyes (choir 1501–18), Brienne-le-Château (lower choir, mid-16th-century), Notre-Dame de l'Epine (begun 1410), and Pamplona Cathedral (1397–1427). Nevertheless, St.-Maclou is the earliest structure to incorporate all these design features into a unified plan. A good selection of Late Gothic plans appears in R. Sanfaçon.

[3] P. Frankl, *Gothic Architecture,* Baltimore, 1960, 177, states that ". . . there was no alteration of the basic type of spatial form, but only of the details, especially those of tracery."

[4] The only major recent monographic study of Flamboyant architecture is S. Murray's *Building Troyes Cathedral. The Late Gothic Campaigns,* Bloomington, Ind., 1987. Through a careful coordination of written sources and archaeological evidence, this pioneering study explores the important relationship between architecture and the economics of building. A recent essay by Rolland Recht, however, begins to examine the context for Late Gothic architecture and takes into consideration the role of drawings, regional diversity, and structural as well as stylistic invention. R. Recht and A. Châtelet, *Automne et Renouveau, 1380–1500* (*Le Monde Gothique*), Paris, 1988, 3–72.

[5] H. Focillon, *The Art of the West,* II, *Gothic,* ed. and intro. J. Bony, New York, 1963, 146. J. Evans expressed the consensus that ". . . since its decorative elements were constant, there was no development of provincial variation. The Flamboyant was a style of extraneous decoration with no constructive principle to dictate innovation in play" (*Art in Medieval France, 987–1598,* London, 1948, 282).

[6] The argument over the English versus indigenous origins of Flamboyant architecture was first developed in a series of debates between C. Enlart ("Origins anglaise style Flamboyant," *Bulletin monumental,* LXX, 1906, 38–81, 511–525, and LXXIV, 1910, 125–147) and A. Saint-Paul, (response to C. Enlart, *Bulletin monumental,* LXX, 1906, 483–510, and *idem,* "L'Architecture française et la guerre de cents ans," *Bulletin monumental,* LXXII, 1908, 5–40, 269–302, 387–426, and LXXIII, 1909, 387–436).



1 St.-Maclou, Rouen, plan, executed in 1899 by Vincent (photo: Caisse Nationale des Monuments Historiques et des Sites, Service Photographique, S.P.A.D.E.M.)

and time to northern France.[7] The vaguely defined "international" character normally attributed to Late Gothic architecture is partially based upon the increase in the number of major artistic centers in western Europe, such as Prague, Brussels, Avignon, and Nuremberg, and the perceived decline in the role of Paris under Charles VI and Charles VII. Thus the axial pier introduced by Peter Parler at St. Bartholomew in Kolin (1360–78), copied at Spitalkirche in Landshut (begun 1407) and the Franziskanerkirche in Salzburg (begun in 1408), was transplanted to Spain's Pamplona Cathedral before arriving in Normandy. These generalizations were based on the assumption that the adoption of major architectural forms was the result of purely aesthetic decisions, made independent of local traditions, building methods, structural considerations, and localized function and meaning. More important, the notion of Flamboyant architecture as representative of the decline of the Gothic and subject to a variety of international influences is contradicted by the visual evidence, which indicates a great technological sophistication evident in the "craft" of masonry, expressed in surviving Late Gothic lodge books and drawings, and borne out in visually complex but supremely elegant and integrated structures like St.-Maclou.

As one of the earliest fully Flamboyant monuments in France, St.-Maclou predates by thirty years the rapid increase in construction and urban expansion following the Hundred Years' War. After 1470 many Northern cities, propelled by expanding wealth and population, experienced frenetic building activity unparalleled at any time in the Middle Ages. Michel Mollat refers to late fifteenth-century Rouen as "un vaste chantier," where "l'exubérance ornementale et recherché du style flamboyant exprime l'opulence bourgeoise."[8] But the high-quality craftsmanship and streamlined vocabulary of forms introduced by Pierre Robin at St.-Maclou in the 1430s set the standard for the dozens of Rouennais parish churches, public buildings, and cathedral and abbey additions carried out after mid-century. The famous cathedral Tour de Beurre of Guillaume Pontis begun in 1467, the central portal of the cathedral designed by Jacques and Roulland Le Roux in 1506, and the luxurious

[7] J. Harvey, *The Gothic World, 1100–1600*, London, 1950, suggested that the axial pier first appeared in Normandy in the choir of Caudebec-en-Caux and then was copied at St.-Maclou and was ultimately derived from the choir of Pamplona Cathedral. As evident in J. Białostocki's seminal article, "Late Gothic: Disagreements About the Concept," *Journal of the British Archaeological Association*, 3rd ser., XXIX, 1966, 76–105, scholars have tended to cast a wide net in defining Late Gothic architecture and tracing its development.

[8] M. Mollat, *Le Commerce maritime normand à la fin du moyen age*, Paris, 1952, 530.

Salle des Procureurs of the Palais de Justice of 1499 are inspired by Robin's continuous fillet moldings, bases, and plinths, fluid tracery patterns, and crisp, polygonal or diagonally-set buttresses. The language of Late Gothic Rouennais architecture is the language of Pierre Robin's St.-Maclou that is first expressed in drawings and the initial stages of construction sometime between 1432 and 1437.

Curiously, this major reassessment of the Gothic canon occurred at an inopportune historic moment. The decade of the 1430s marked a turning point in the English occupation of Normandy. Rouen had served as the administrative center for the Duke of Bedford since the capitulation of the city in 1419. By the 1430s, English power and popularity had begun to decline, and it became apparent that they could no longer guarantee the trade privileges and economic stability essential for the commercial prosperity of the Rouennais bourgeoisie and especially the cloth merchants and patrons of St.-Maclou.[9]

In this climate of political instability and economic uncertainty, the patrons of St.-Maclou undertook the rebuilding of their thirteenth-century chapel. Initially motivated by a dire need to repair the recently collapsed transept, they decided instead to rebuild in a lavish, expensive, and ultimately radically new style based on the drawings of a Parisian architect. A letter issued by Henry VI in 1446 makes it clear that the parish had neither funds nor stone of good quality to undertake the rebuilding of their church, but nevertheless they began.[10]

Shortly after 1432, the Flamboyant church was begun, to the east of the old thirteenth-century nave. After the outer envelope of the chevet was constructed, work returned to the transept. The choir chapels and ambulatory were vaulted, the old nave destroyed, and construction began on the new nave. The vaults of the central vessel of the choir were erected shortly before those of the nave, and the west façade and porch were in place by 1490. There are no apparent seams in construction to indicate breaks, and work progressed at an uninterrupted, albeit sometimes slow, pace from the 1430s to 1489, when the western rose window was inserted. Although the church was not dedicated until 1521, only details of the superstructure and the lantern tower remained incomplete after 1490. For much of this period work was carried out by the same *appareilleurs*—Jehan Le Prevost and Friset Le Mestre—who closely followed the plans of the original master mason, Pierre Robin.[11]

The bleak political and economic environment of the early fifteenth century did little to foster ambitious architectural projects in Rouen. With few exceptions construction was limited to restorations, fragmented additions, and completion of existing monuments. At the cathedral of Rouen, the master mason Jenson Salvart was occupied between 1406 and 1441 with the completion of the west façade and the enlargement of the clerestory windows.[12] At the same time Jean de Bayeux II and Alexander de Berneval, consecutive masters of the abbey of St.-Ouen, continued the century-long construction of the transept, south porch, and crossing tower. Much of this work was cosmetic and provided no appropriate vehicle for the expression of a coherent and systematic approach to design. During the first decade of the occupation of Rouen, these famous architects were primarily engaged in the construction of the Vieux Palais for Henry V. On a smaller scale, the wealthy merchant Robert Alorge commissioned the construction of a chapel for the Cordeliers in 1402, and after 1419, repair work was carried out on a number of parish churches that were damaged or demolished during the siege and occupation of the city.[13] Small masons' workshops were active at St.-Gervais in 1434, St.-Hilaire and St.-Paul in 1438, St.-Michel in 1426, and the priory of St.-Lo in 1441, carrying out minor restorations and rebuilding.[14] But until the construction of St.-Maclou in the 1430s, no major, expensive, and complete monument expressing a comprehensive vision of Gothic architecture had been undertaken in Rouen since the completion of the choir of St.-Ouen, almost one hundred years earlier.[15]

Little is known about Pierre Robin's career in Paris and no other monuments have been attributed to him on the basis of style. He was employed in Paris as master of the works of the city and master mason of the cathedral of Notre Dame between 1412 and the 1430s, but no extant works survive. Problematic portions of the Parisian churches of St.-Séverin, St.-Nicolas-de-Champs, and St.-Germain-l'Auxerrois have been dated to the first quarter of the fifteenth century, but nowhere can one find a hint of Robin's dynamic vocabulary or unorthodox designs. There is no evidence that he learned church plan design from first-hand experience or from contemporary monuments in Rouen or Paris. The complex

[9] For a discussion of the economic conditions in Rouen during the English occupation of the city, see P. Le Cacheux, *Rouen au temps du Jeanne d'Arc et pendant l'occupation anglaise (1419–1449)*, Rouen, 1931, and Mollat (as in n. 8). The impact of politics and economics on the conception of St.-Maclou is discussed in my article, "The Flamboyant Architecture of Saint-Maclou and the Development of a Style," *Journal of the Society of Architectural Historians*, XLVII, 4, Dec. 1988, 374–396.

[10] The letter of amortizement issued by Henry VI at Windsor on April 22, 1446 encourages the parishoners to support the construction of their new church, which was begun without *deniers* or good stone. Rouen, Archives départementales, Seine-Maritime, G7040 (loose parchment).

[11] Jehan Le Prevost and Friset Le Mestre are mentioned in the fabric accounts of both 1443–46 and 1476–79. They are paid less than the master mason, are working on a daily basis, and bear the title of masons. Work at the same time is being supervised by a number of other masons, including Oudin de Mantes (listed along with Pierre Robin in the 1436–37 account as master), Simon Le Noir (working with Pierre Robin at both St.-Yves, Paris, and St.-Maclou), Jehan Chauvin (working in 1454), and Ambroise Harel (working between 1467 and 1480). Neagley, 379.

[12] The best summary of Rouennais architecture during this period is provided by C. de Robillard de Beaurepaire, "Notes sur les architectes de Rouen," *Bulletin des amis des monuments Rouennais*, 1901, 75–96; 1902, 67–93.

[13] The contract for the construction of the chapel of the Cordeliers has been published by C. Robillard de Beaurepaire, "Devis pour la construction d'une chapelle aux Cordeliers de Rouen (1402)," *Bulletin de la Commission des Antiquités de la Seine-Inférieure*, VIII, 1888–90, 216–220.

[14] M. Mollat, "Une Expansion différée par la guerre (1382-environ 1475)," *Histoire de Rouen*, ed. M. Mollat, Toulouse, 1979, 136.

[15] One exception may have been the monastery of the Chartreuse, founded near the porte St.-Hilaire in 1385. The construction of the new church and chapel was completed by 1392 and included a church, chapter house, library, and 200-foot square cloister. The churches are illustrated in the *Livre des fontaine* of 1525, but nothing remains of the original structures. See T. Jolimont, *Les Principaux édifices de la ville de Rouen en 1525*, facs. ed., Rouen, 1845, 25.

and intricate knowledge required to coordinate plan design, structure, elevation proportions, and details of articulation must have been extrapolated from lessons acquired in his training as a mason and must constitute nothing less than a "theory of plan design."

Thus, through an examination of Pierre Robin's plan, this study will address four fundamental questions. An attempt will be made to identify the geometric design schemes that determined the proportional and spatial divisions of the plan at St.-Maclou and to demonstrate how the unusual features of the plan are linked to the geometric configurations that underlie the design. Secondly, these abstract design schemes can only be accepted if they provide an efficient and economic blueprint for setting out the foundations at the site. They must be easily translated into a practical procedure of constructive geometry used in marking and locating the placement of foundations walls and piers. While these first two questions can be answered with some certainty, a third issue is more speculative. Because of the uniformity of the plan of St.-Maclou, the small scale of the monument, and the apparent precision with which it was executed, it is possible to recover the design scheme with great accuracy. This is not true for most Gothic buildings, whose plans were frequently adjusted over the course of construction. However, it seems reasonable to assume that guidelines existed for the design of Gothic church plans. These rules provided a common language or working method that could be passed from master to apprentice and that was understood as the proper way to design a plan, flexible enough to respond to diverse demands of individual monuments and patrons, but uniform enough to insure proper proportional, structural, and aesthetic results. Because of the tremendous complexities involved in the construction of thirteenth-century cathedrals, the inaccuracies of existing modern plans, and the lack of a consistent methodology in design analysis, it has been impossible to identify whether there exists a uniform and coherent system or theory of plan design shared by groups of Gothic monuments. The method of design, more easily extracted from a Late Gothic church that was executed under ideal conditions, might serve as a point of departure for unraveling the design and layout of other Gothic structures. Perhaps a greater understanding of the initial creative sequence that fashioned the structure, space, and mass of St.-Maclou will provide a clarification of procedures used in the design and layout of the thirteenth-century French cathedral. Finally, it is through a study of plan design that a new criterion for the consideration of Flamboyant architecture emerges.

There are no comparable studies in plan design of Flamboyant architecture, and the few detailed studies of thirteenth-century High Gothic church plans have not been concerned with the identification of a uniform and theoretical basis for plan design.[16] The geometrical knowledge of the medieval mason, his design procedures, drawings, and tools have interested the scholar of medieval buildings for many generations. Because of the absence of architectural treatises from the Middle Ages, historians have sought to explain the mental processes involved in the conception and layout of Gothic buildings through an examination of lithic evidence, written sources, and surviving drawings.[17] While there is little doubt that progressive squaring was a basic design tool, as has been frequently demonstrated in the design of towers, façades, piers, etc., its use in overall plan design has been relatively unproven in French Gothic buildings.[18] A distinction must also be made between the design of details of buildings, such as piers, shafts, buttresses, mullions, window tracery, and towers, and the design intended for the layout of an entire church. In the former, a different set of tools was used. Dividers, compasses, units of measure, and squares marked off proportional relationships on parchment or stone. The template became the pattern by which forms and relationships were encoded and conveyed to the mason.

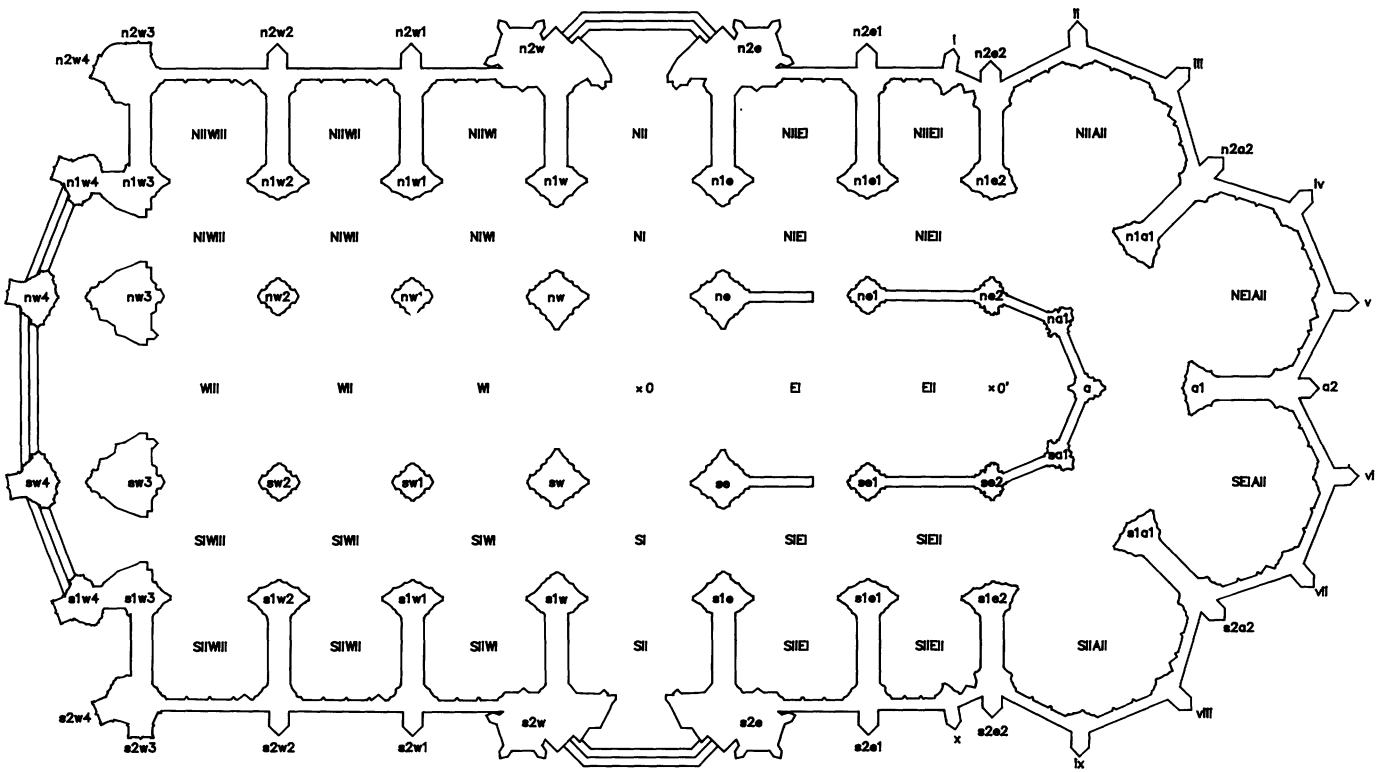
The design of an entire church that guided the layout of foundations or the relationship of chapels to bays to aisles must, however, have been expressed in a different fashion. The few surviving medieval plans do not indicate proportional or design schemes.[19] Square schematism is the basis

[16] Important recent studies on 13th-century plan design include Murray, 533–551, on Beauvais, and Murray and Addiss, 44–65, on Amiens; Prak, 209–212, on Amiens; Davis, 1984, 130–160, on Altenberg Abbey; J.R.H. James on Chartres Cathedral, *The Contractors of Chartres*, Wyong, Australia, 1981 (see chap. 8, "The First Plan," 133–166). Murray and Addiss's 1990 conclusions regarding the plan of Amiens, especially concerning the role of the transept in the overall plan design scheme, reveal striking similarities with the procedure used at St.-Maclou.

[17] Much of the literature on building technique, design, drawings, and masons has been gathered and summarized in the recent exhibition catalogue, *Les Batisseurs des cathédrales gothiques*, ed. R. Recht, Strasbourg, 1989. Lon R. Shelby and François Bucher have contributed significantly to an understanding of the craft of masonry through a study of late medieval German lodge books and drawings. See, for example, Shelby (in Sources) and *idem*, "Medieval Masons' Templates," *Journal of the Society of Architectural Historians*, XXX, 2, 1971, 140–154; F. Bucher, "Design in Gothic Architecture: A Preliminary Assessment," *Journal of the Society of Architectural Historians*, XXVII, 1, 1968, 49–71; and *idem*, "Medieval Architectural Design Methods, 800–1560," *Gesta*, XI, 1972, 39–51. Late Gothic plans and drawings have been published by H. Koepf (*Die gotischen Planrisse der Wiener Sammlungen*, Vienna-Cologne, 1969); P. Pause (*Gotische Architekturzeichnungen in Deutschland*, Bonn, 1973), and O. Kletzl (*Plan-Fragmente aus der deutschen Dombauhutte von Prag in Stuttgart und Ulm*, Stuttgart, 1939).

[18] For analyses of square schematism and progressive squaring as applied to various parts of buildings and drawings, see the following: F. Bucher, *Architector. The Lodge Books and Sketchbooks of Medieval Architects*, I, New York, 1979, 76–77, for Villard's tower at Laon and the design of the Lausanne rose window; S. Murray, "The Gothic Façade Drawings in the 'Reims Palimpsest,'" *Gesta*, XVII, 1978, 51–55; and M.T. Davis, "'Troys Portaulx et Deux Grosses Tours': The Flamboyant Façade Project of the Cathedral of Clermont," *Gesta*, XXII/1, 1983, 67–83, for façade design; M. Velte, *Die Anwendung der Quadratur und Triangulatur bei der Grund- und Aufrissgestaltung der gotischen Kirchen*, Basel, 1951, for tower design. The use of the $\sqrt{2}$ square in determining overall dimensions has been demonstrated in several studies on English Romanesque buildings by E. Fernie; "The Grid System and the Design of the Norman Cathedral," *Medieval Art and Architecture at Winchester:* Conference Transactions, British Archaeological Association, 1983/4, 13–19.

[19] Robert Branner lists four extant French medieval drawings or groups of drawings, none of which represent plans (and no French or English plan drawings survive, aside from the brief sketches in Villard's portfolio), "A Fifteenth-Century French Architectural Drawing at the Cloisters," *Metropolitan Museum of Art Journal*, XI, 1976, 133–136. The parchment in the Museé de l'Oeuvre at Strasbourg illustrating the plan of Notre-Dame, Paris, with the plan of St.-Croix, Orleans on the reverse was made and preserved by a German workshop; see O. Kletzl, "Ein Werkriss des Frauenhauses von Strassburg," *Marburger Jahrbuch fur Kunstwissenschaft*, XI–XII, 1938–39, 103–158. For numerous German plans, see the reproductions in Koepf and Pause (as in n. 17). One of the most detailed contemporary plan drawings is of Ste.-Waudru in Mons (see K.J. Philipp, "Die Planungsgeschichte einer Stiftskirche 1449–1450," *Zeitschrift fur Kunstgeschichte*, III, 1988, 372–413).



2 St.-Maclou, Rouen, plan, nomenclature (drawing: H. Shih)

for Villard's plan of a Cistercian church, but no other extant plans indicate progressive squaring, *diagons,* or dimensions to demonstrate the guidelines for plan design. The design and layout of the great Gothic cathedrals of thirteenth-century France have for the most part defied simple explanation.[20] Plans may have been less codified and drawings were an *ad hoc* part of construction, continually modified by site limitations, patronal desires, structural demands, and changes in architects, campaigns, and funding—hence their underlying schemes have become indecipherable. But perhaps the greatest obstacle to deciphering plan designs of Gothic cathedrals has been the absence of reliable and carefully reconstructed modern plans with precise dimensions.[21]

St.-Maclou is the ideal candidate for the study of Late Gothic plan design.[22] There is clear evidence that the plan was the work of a single architect; control over the dimensions was facilitated by the small scale of the monument; drawings were used to provide continuity and consistency to the execution over the period of construction; there were no site limitations that forced the masons to deviate from the initial plan; and the church was executed in expensive, fine-grain limestone from the quarries of Vernon which allowed for precise and accurate carving.[23] The close correspondence between ideal conception and actual execution facilitates the recovery of the initial abstract scheme that guided Pierre Robin as he traced his ideas on parchment.

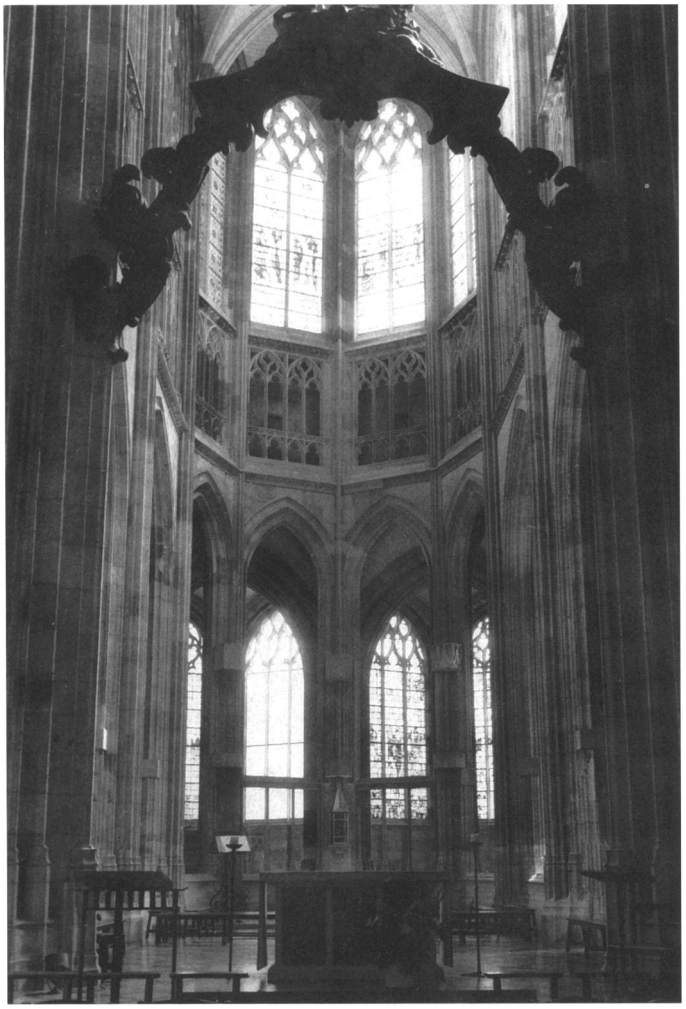
The plan of St.-Maclou is compact, regular, and uniform (Fig. 2). It includes a nonprojecting transept with enlarged crossing piers that support a lantern tower centrally placed between the short, three-bay nave with side aisles, and a

[20] As Murray has pointed out for Beauvais (p. 539), the architect often relied on intuitive decisions in the placement of the hemicycle center. James's analysis of the plan of Chartres underscores the complexity of laying out a building, and his measurements indicate an indecipherable scheme, probably due to continual readjustments and changes during the process of construction (as in n. 16, 1, 159). James also argues for intentional deviation from an ideal plan in "Discrepancies in Medieval Architecture, Careless or Deliberate?" *Architectural Association Quarterly,* XIII, 4, July–Dec. 1982, 41–48. Because of the unity in the underlying geometric skeleton at Amiens, Murray and Addiss have recently suggested that Robert de Luzarches provided an entire drawing of the plan on parchment, plaster, or stone (p. 45).

[21] An essential component of the present study involved the development of a uniform and precise methodology for the survey and drafting of a new plan of St.-Maclou, as outlined in the Appendix. This analysis is based on a computer-generated plan derived from digital planimetric survey data gathered in the summer of 1988 (Fig. 2). A more precise plan was needed to replace the one executed in 1899 by Vincent. Although beautifully drawn, Vincent's plan recorded multiple horizontal layers, including window mullions, wall setbacks, and vaulting patterns, as well as the basic configurations of chapels, aisles, and placement of piers. Due to the complexity of the pier sections, they were sketched in with little consideration for their actual dimensions. The exact size and placement of the piers and walls of the choir would have been impossible to determine in the late 19th century when the plan was drawn because the hemicycle and chapel piers and walls were still encased in an 18th-century wooden wainscotting.

[22] See the plan analyses of Late Gothic German architecture by Luc Mojon and Herbert Hufnagle: L. Mojon, *Der Münsterbaumeister Matthaus Ensinger,* Bern, 1967; H. Hufnagle, "Zur Baugeschichte des Ostchors des Augsburgers Domes," *Architectura,* I, 17, 1987, 32–44. However, neither Mojon nor Hufnagle or any of the studies on French Gothic plan design have demonstrated the relationship among progressive squaring, chronology of construction, and the practical procedure of establishing the plan on the ground.

[23] The cemetery, situated near the entrance of the church and referred to as an *aître* (from *atrium*), functioned as the masons' lodge during the construction of the church. Although the building accounts of 1436–37, 1443–46, and 1476–79 still list revenues from burial in the *petit aître,* they also cite the cemetery as a dump for stone delivered from the docks of the Seine. Rouen, Archives départementales, Seine-Maritime, G6874, G6876, and G6878.



3 St.-Maclou, Rouen, interior, general view (photo: L. Neagley)

relatively large choir consisting of two straight bays, aisles, and four polygonal radiating chapels. Deep chapels, created between the internalized buttressing, line the aisles of the nave and choir. The nave is preceded in the west by a three-sided polygonal porch surmounted by five gables. At ground level there are four polygonal staircase turrets, two flanking the north transept and two flanking the south transept.

The plan is distinguished from earlier Gothic monuments by the presence of an axial pier in the center of the hemicycle and the absence of an axial chapel, a polygonal porch before the west façade, a lack of uniform size in the straight bays of the choir and nave, and an emphasis on the transept crossing. In addition, the structural system is absorbed entirely within the body of the church, with only small wall buttresses projecting on the exterior nave and choir chapels. All of these features were generated from the proportional and structural systems established by the plan and characterize the fluid relationship between mass and space typically associated with Late Gothic architecture.

The hemicycle of St.-Maclou is designed around half an octagon resulting in an axial pier and an even number of identical radiating chapels (Fig. 3). The generous size of the four radiating chapels compensates for the lack of an axial chapel, but this unorthodox treatment of the chevet is particularly puzzling considering that a number of axial chapels in Normandy were either rebuilt or enlarged in the fourteenth and fifteenth centuries in response to the cult of the Virgin and the growing power and importance of confraternities dedicated to her veneration.[24]

Porches were also indigenous to Rouennais architecture and had been added to the neighboring abbey of St.-Ouen and Rouen Cathedral. The porch of the Marmousets attached to the south transept of the abbey of St.-Ouen was begun in the late fourteenth century by Jean de Bayeux and completed by his son of the same name around 1400. Around 1370 a porch was designed but perhaps never completed for the west façade of the cathedral of Rouen by Jean Perier. Perier's porch was replaced with the rebuilding of the central west portal by Jacques and Roulland Le Roux in the early sixteenth century, but vestiges of the porch vault shafts and springers remain tucked behind the massive buttresses designed by Le Roux. The liturgical functions of these porches do not, however, apply to the parish church, and the elegant, polygonal design of the St.-Maclou porch has little formal resemblance to its local precedents (Fig. 4).[25]

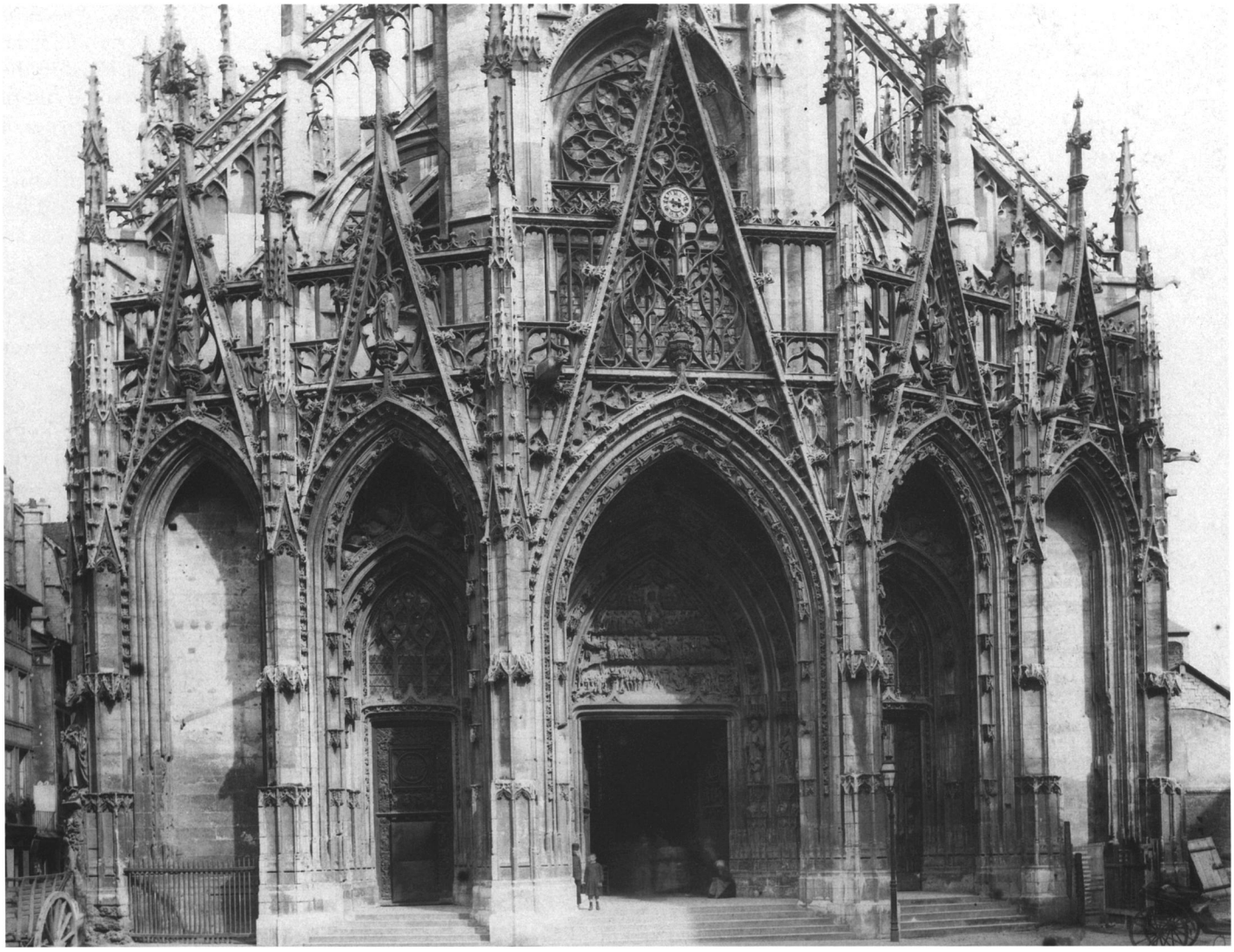
While the layout of most large-scale structures indicates a desire for regularity of bay size, all the straight bays at St.-Maclou are of different dimensions, increasing in size from the western nave to the transept and then decreasing from the transept to the hemicycle; averages from west to east are 5.154m (from inner wall), 5.417m, 5.857m, 6.744m (transept), 5.874m, and 5.050m (Fig. 5).[26] It seems unlikely that this lack of uniformity in a small-scale building is the result of continued readjustments or carelessness in laying out the bays; rather, it reflects the incommensurable geometric relationship between bays established by the design scheme.

The restoration reports on St.-Maclou, written after damage to the church in 1944, state that the master mason of the church pushed the structure to the limits of the laws of equilibrium. According to Albert Chauvel, the dimensions of piers, walls, and supports were reduced to their absolute

[24] Larger axial chapels were added to the Norman cathedrals of Rouen (1302), Coutances (ca. 1371–86), Lisieux (ca. 1432), Evreux (ca. 1470), and the abbey of La Trinité at Fecamp (begun 1489).

[25] The function of the porch of the Marmousets on the south transept of this royal abbey is not clear. Neither has a function been attributed to Perier's porch at the cathedral, but it was added at the same time as the first mention of a "viri galilae" in the documentation (C. Jouen, *La Cathédrale de Rouen,* Rouen, 1932). This was part of the liturgy preceding the festival of the privilege of Saint Romain, when two canons mounted the façade and sang a response. The location of the "viri galilae" above the central portal is established by another document, of May 30, 1508, concerning the rebuilding of the central portal and platform by Le Roux (Rouen, Archives départementales, Seine-Maritime, G2147). It seems likely that this platform above the porch functioned much like the ones at Wells and Salisbury. See P.Z. Blum, "Liturgical Influences on the Design of the West Front at Wells and Salisbury," *Gesta,* XXV, 1, 1986, 145–150. For a complete discussion of the west facade porch and its function and meaning, see J. G. Chung, "The West Façade of Rouen Cathedral: Sources and Meaning," Master's Essay, University of Michigan, Ann Arbor, 1991.

[26] These distances are mean averages of the two sides of the bays identified on the grid dimension plan (Fig. 5).



4 St.-Maclou, Rouen, west façade (photo: Caisse Nationale des Monuments Historiques et des Sites, Service Photographique, S.P.A.D.E.M.)

minimum.[27] It is generally thought that the late medieval mason determined the size of supports according to proportional relationship between the diameter of the support and the span of the arch or bay. For example, the German Lodge Book "Instructions" written in 1516 by Lorenz Lechler, the only surviving book that deals with ground plan design, suggest that the ratio of the width of the choir to the wall thickness be 1:10.[28] Can a close examination of the dimensions and proportions of the plan of St.-Maclou reveal Pierre Robin's understanding of the structural dynamics of a small-scale monument, and is this structural system fundamentally different from that of the thirteenth-century cathedral? An analysis of the plan suggests that Pierre Robin compensated for the reduced dimension of the arcade piers by reassigning their structural role to other parts of the building.

The Design Schemes of Pierre Robin's Plan

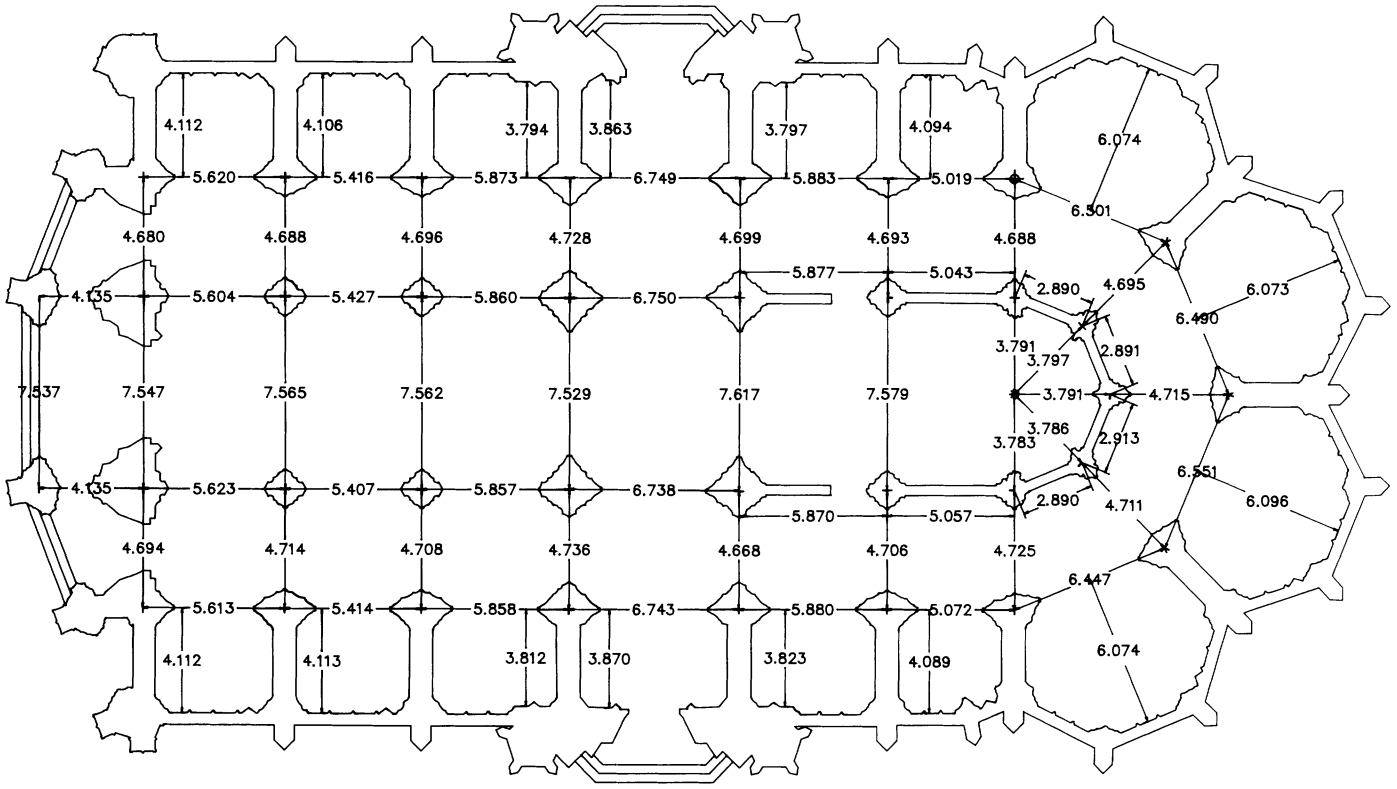
For Pierre Robin, the transept was the generative center for design, mass, and space. The polygonal porch, angled gables, and buttress design on the exterior create a series of diagonal recessions that culminate with the lantern tower placed midway between the nave and choir (Fig. 6). The lantern tower, rising to a height of approximately eighty-five meters, dominates the exterior massing.[29] On the interior, the narrow central vessel of the short nave and choir rises dramatically under the corona of light at the lantern crossing. Not only is the transept experienced as the visual climax of the exterior massing and interior space, but it is the fundamental design center from which all other dimensions of the plan are derived.

From the St. Gall plan of the ninth century, to Cistercian

[27] A. Chauvel, "L'Église Saint-Maclou de Rouen, Destructions et Consolidations," *Les Monuments historiques de la France,* IV, 1958, 164–165.

[28] L. R. Shelby and R. Mark, "Late Gothic Structural Design in the 'Instructions' of Lorenz Lechler," *Architectura,* IX, 1979, 118–119.

[29] The stone spire over the lantern was constructed in 1867 by Barthélemy, replacing the original wooden spire built by the master carpenter Martin Desperrois in 1517. The medieval wooden spire, destroyed in the storms of 1706, 1736, and 1794, can be visually reconstructed from an illustration of the church in 1525 in the *Livre des fontaines,* and from the cardboard model of the church dating sometime after 1521 and presently located in the Musée des Beaux-Arts in Rouen. It was approximately the same height as the present stone replacement.



5 St.-Maclou, Rouen, grid dimensions (drawing: H. Shih)

churches of the twelfth century, a square module derived from the transept served as an easily divisible unit that provided dimensions for aisles, chapels, and central vessel widths.[30] By the thirteenth century, the transept crossing bay was often rectangular, but the bays adjacent to the transept on the east and west were larger than the other straight bays and, when included with the transept crossing bay, formed a square used to determine other dimensions.[31] But the clear and precise role of the transept demonstrated in these structures is not readily apparent in High Gothic buildings. However, at St.-Maclou, all the major overall dimensions—the length of the choir and nave as well as the dimensions of the individual bays—are determined by a simple design scheme generated from the transept crossing and the adjacent bays.

The crossing bay of St.-Maclou is rectangular, but when combined with the adjacent bays of equal dimensions, it forms a 18.474m square (Fig. 7).[32] When this square is rotated, the diagonal of the square (which bears a $\sqrt{2}$ relationship or 1:1.414 to the side of the square) precisely identifies the width of the church at the transept to the outside exterior wall. This simple module sets up the relationships that will be used throughout the rest of the church.

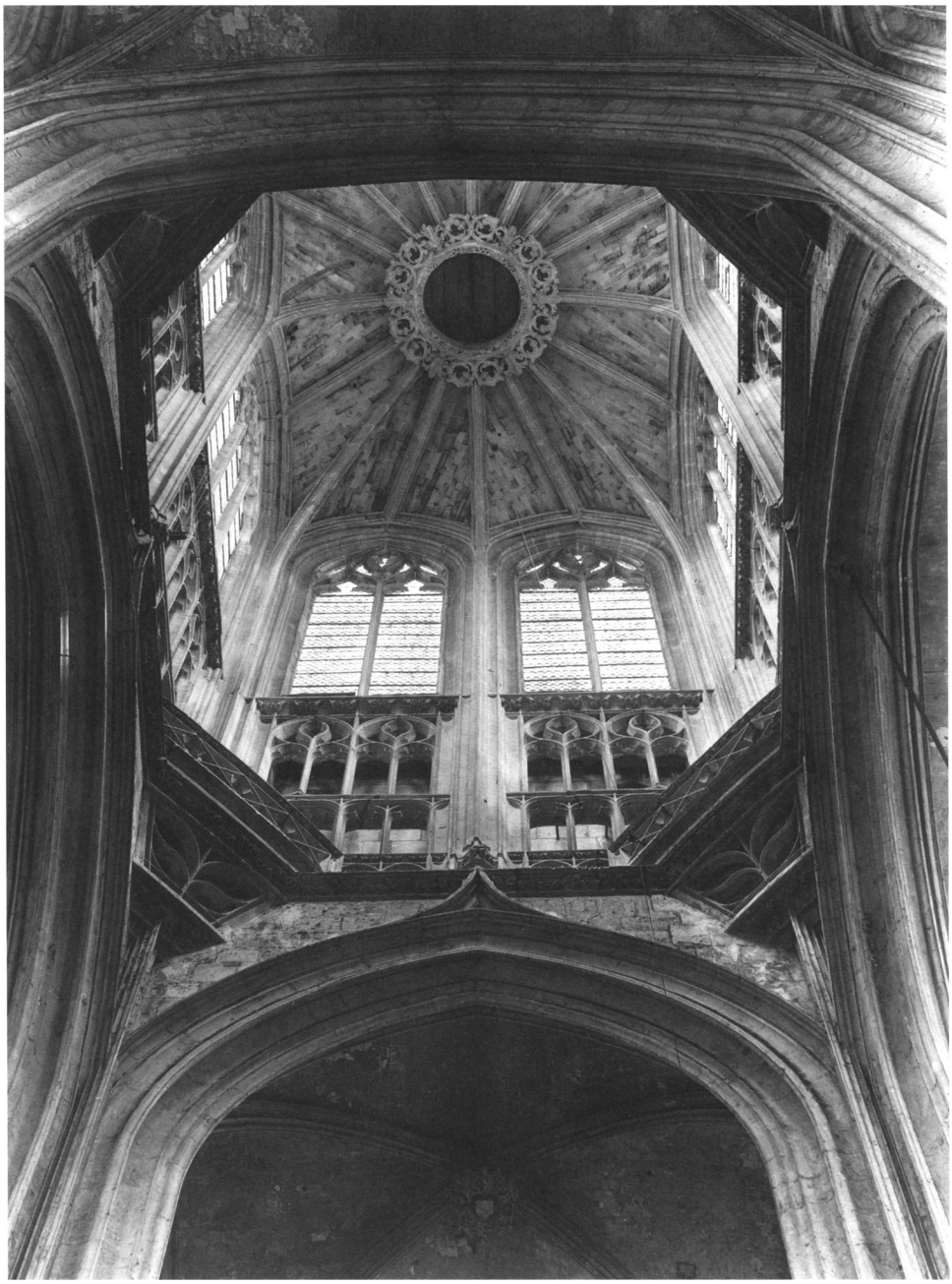
A grid formed by connecting the points of intersection of the rotated transept square creates the dimensions of 5.411m and 7.652m (a $\sqrt{2}$ relationship). Pierre Robin uses the 7.652m dimension as the width of the transept and the 5.411m as the width of all the straight bays (Fig. 8). The irregularity of bay size is only apparent if measurements are taken from the center points of the piers and walls, as they are in Fig. 5.[33] Robin avoided the static regularity of additive

[30] For the St.-Gall plan, see W. Horn and E. Born, *The Plan of St Gall*, 2 vols., Berkeley, 1979. For Cistercian planning, see H. Hahn, *Die frühe Kirchenbaukunst der Zisterzienser*, Berlin, 1957, 236–238. Villard's drawing of an ideal Cistercian church leaves little doubt as to the importance of the transept square; see H. Hahnloser, ed., *Villard de Honnecourt. Kritische Gesamtausgabe des Bauhuttenbuches ms. fr. 19093 der Pariser Nationalbibliothek*, 2nd ed., Graz, 1972.

[31] The transept square at Amiens also consists of the crossing bay and adjacent bays (32.8 m × 31.85 m); see Prak, 210. Murray and Addiss, p. 64, establish the transept and adjacent bays as the primary design element. At St.-Denis the square transept includes the aisles and functions as a "central planned" royal mausoleum, as suggested by C. Bruzelius, *The 13th-Century Church of St Denis*, New Haven, 1985, 33–42.

[32] The crossing square is 6.744 m east-west × 7.573 m north-south. These are mean averages of the dimensions that appear in Fig. 6. The adjacent bays are within 2 cm (using mean averages of 5.856 m in the nave and 5.874 m in the choir). Therefore, 5.856 m + 6.744 m + 5.874 m = 18.474 m. 18.474 m is referred to hereafter as the transept macro module. The width of the church to the outside wall does not vary significantly among the nave, transept, and choir—26.101 m at chapel NIIWII through SIIWII in the nave, 26.126 at NII through SII in the transept, and 26.078 m at chapel NIIEII through SIIEII in the choir.

[33] To determine the breadth (east-west dimensions) of the transept based on 7.652 m, Robin included the thickness of the walls separating the transept from the side chapels (Fig. 10). The straight bays of the choir and nave were then determined by the 5.411 m module, but as the grid was established moving east and west away from the transept, the centers of the chapel walls were used, creating bays of different dimensions. The easternmost straight bay of the choir once again included the thickness of the chapel wall, while the grid line that determined the westernmost straight bay of the nave was found inside the western façade wall. Thus, the bays from west to east measure 5.411 m, 5.416 m, 5.411 m, 7.652 m (transept), 5.411 m, and 5.451 m (Fig. 10). These dimensions, read from the base plan by the computer, identify a remarkable consistency in setting out the nave dimensions.



6 St.-Maclou, Rouen, pre-World War II photograph, interior, lantern tower (photo: Bildarchiv Foto Marburg)

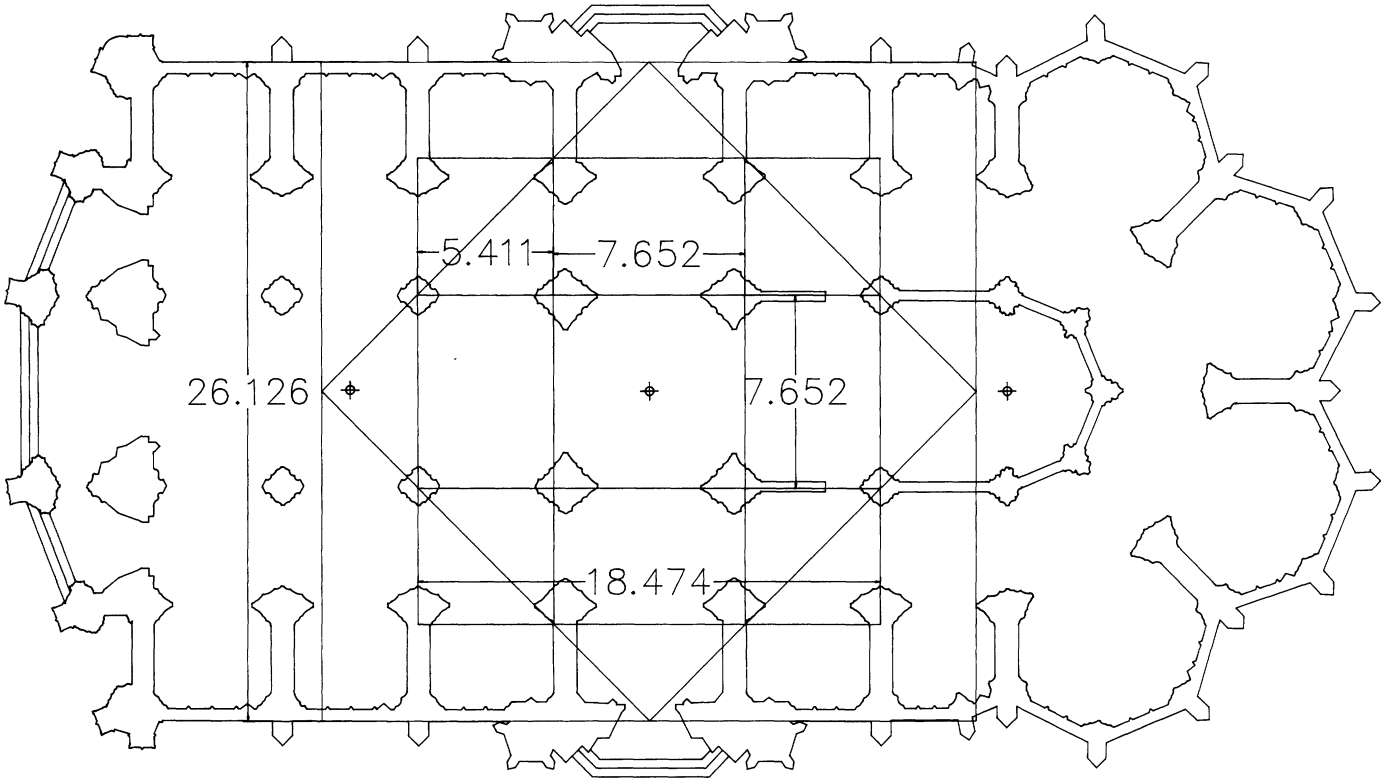
bays and created an expansive and contractive space (unfolding at the transept) by varying the placement of these points in relationship to the piers and walls.

The width of the central vessel (an actual mean average of 7.568m) is not provided by the transept macro module (7.652m), however. Robin achieves a greater sense of verticality and illusionism by using a contracted dimension, an aesthetic that is clearly extended to other proportions of his design. On the other hand, an overall length of the plan (an east-west dimension of 52.252m) is provided by the transept macro module when it is generated from the nave center point (*02*) and from the hemicycle center point (*0'*). Thus the ratio of width to length of the church is a simple 1:2 (Fig. 9).[34]

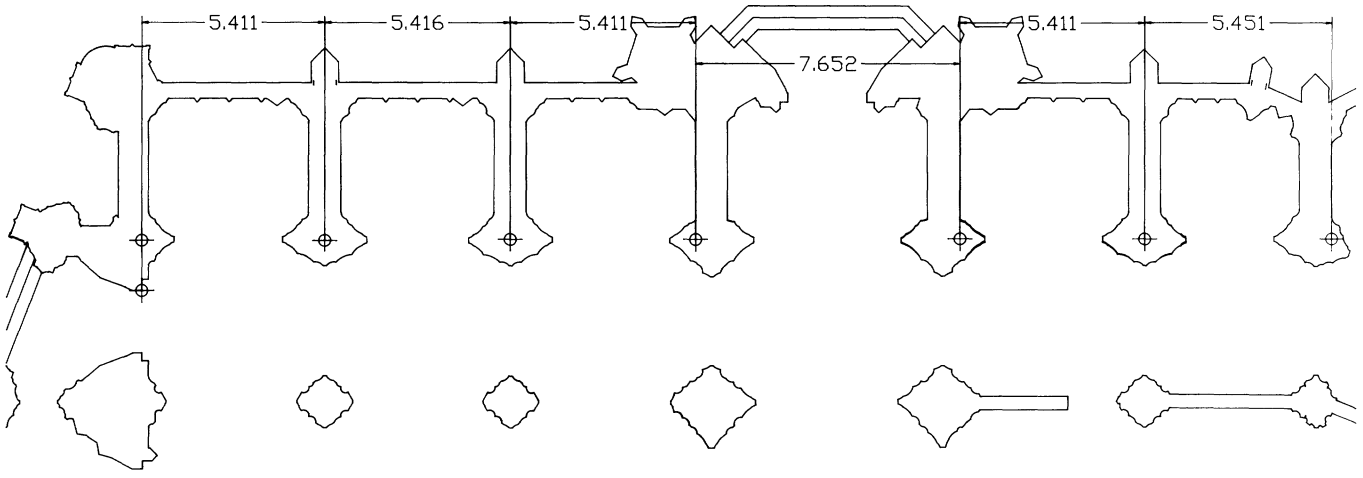
Robin arrived at a supremely elegant and uncomplicated solution to fashion the more complex arrangement of the radiating chapels, ambulatory, and hemicycle.[35] The placement of the hemicycle piers was determined by the single rotation of a square based on the width of the central vessel (7.574m, Fig. 10). A second pair of rotated squares based on the width of the central vessel and aisles (16.987m) established the centers of the chapel-opening piers with the first pair of squares and the depth of the chapel-opening piers

[34] The same method used to derive the overall dimensions of the chevet from a square was demonstrated by M. Davis at Altenberg (pp. 132–133). Davis also takes his measurements to the outer wall.

[35] Using centerpoints marked between the chapel-opening piers of the four radiating chapels, the angles read with the theodolite from the center of the hemicycle *O'* are within 30″ (seconds) of 45 degrees—a precision that is remarkable even by modern engineering standards.



7 St.-Maclou, Rouen, plan design scheme, transept macro module (drawing: H. Shih and L. Neagley)



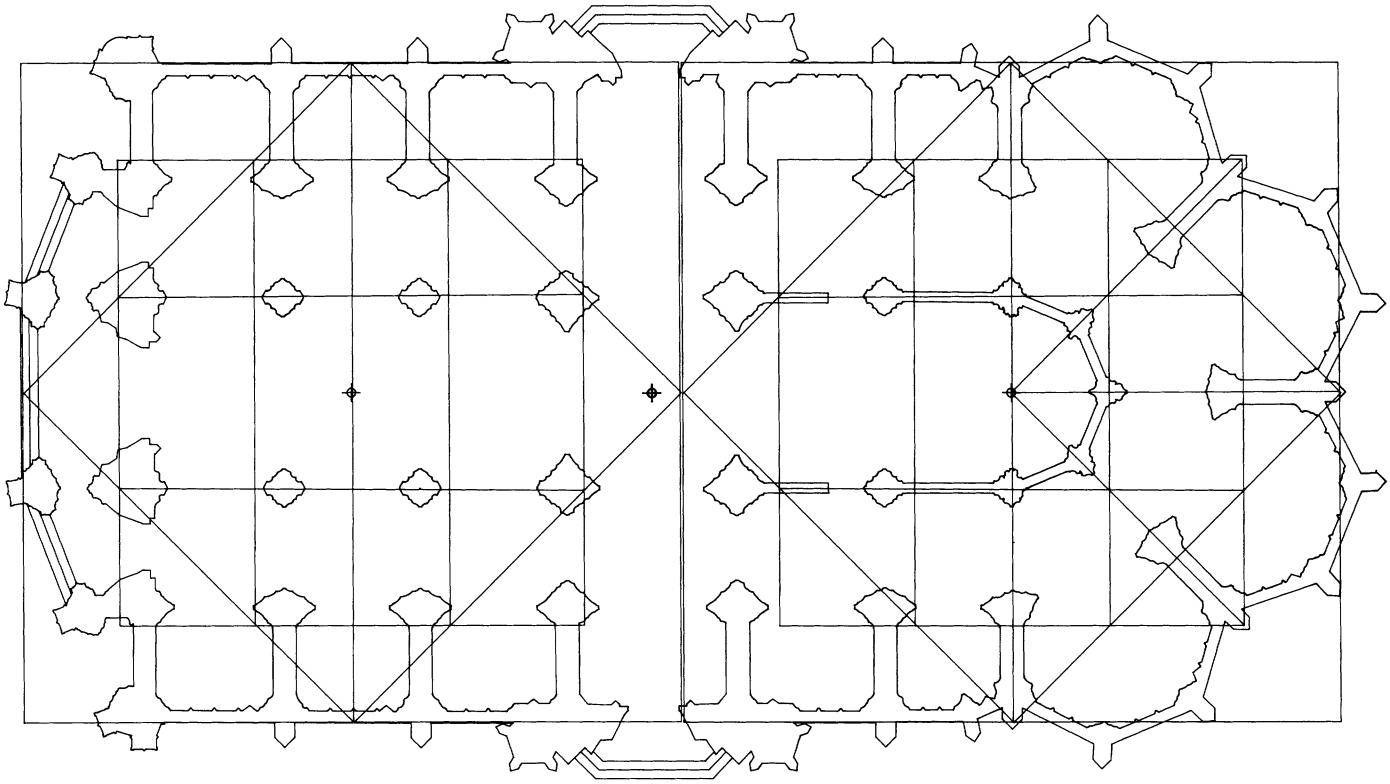
8 St.-Maclou, Rouen, plan, dimensions of straight bays, north side (drawing: H. Shih and L. Neagley)

with the second pair of squares. A third pair of squares in the same progression, but rotated at 22.5 degrees, located the outer walls of the chapels. Thus the depth of the walls dividing the chapels is also determined by $\sqrt{2}$ relationships and the choir geometry is compatible with the transept module as well as independent of it.

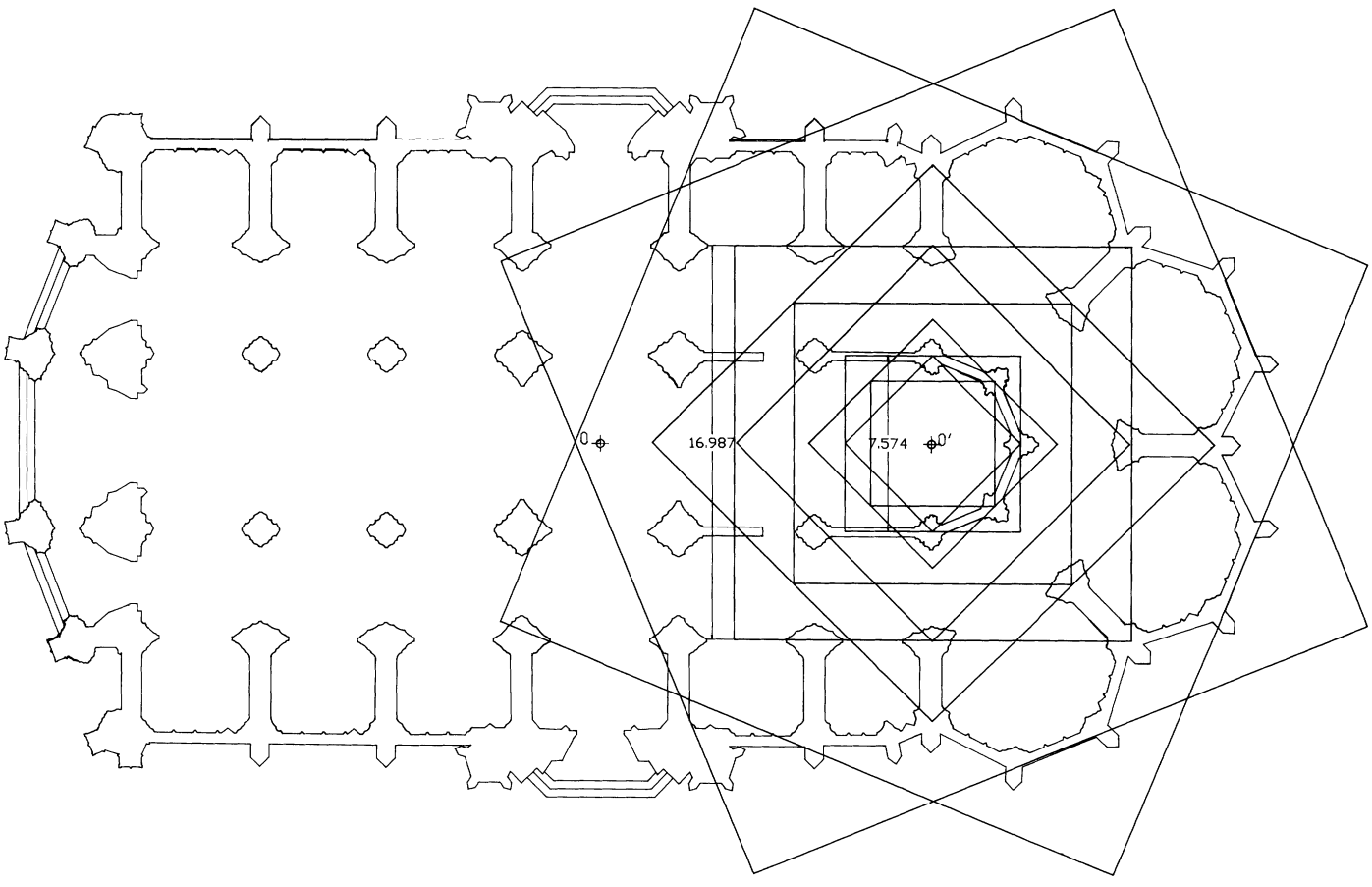
Although the radiating chapels appear to be irregular hexagons, they too are designed around a single rotated square, so that the depth of the chapel (to the outside wall) is equal to the width of the chapel opening (Fig. 11).

As previously demonstrated, the dimensions of the individual nave bays and the overall length of the nave were derived from the transept macro module, but the puzzling angles of the western porch remained unexplained. Although there are five gables, the plan is designed around a three-sided polygon. In spite of its visual complexity, the polygonal shape of the western porch was created by a single rotation of the transept square of 26.126m generated from the center nave bay point *O2* (Fig. 12). The unusual angle of the north and south porch entrances is established by a 22.5-degree rotation of the same square that determined the width of the church. Nothing could be simpler.

Thus, there is a unity in the design of the east and west ends. The beveled planes of the western porch are complemented and mirrored by the sharply delineated spaces formed by the axial pier in the hemicycle. Equally unorthodox in



9 St.-Maclou, Rouen, plan, overall design scheme based on transept macro module (drawing: H. Shih and L. Neagley)



10 St.-Maclou, Rouen, plan design scheme, east end (drawing: H. Shih and L. Neagley)

design, both are based on the transept dimensions, and their unique polygonality can be ascribed to variations on the rotation of the transept square (26.126m square) by 22.5 degrees.

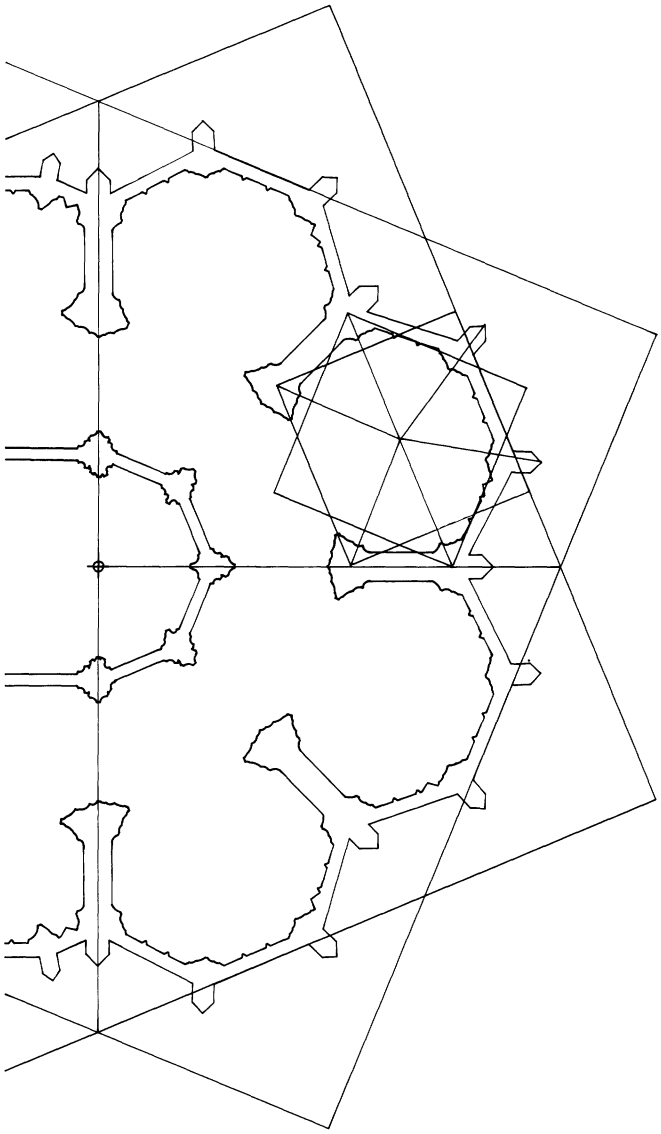
The most massive and irregular masonry of the church frames the central portal, buttresses the west façade, and supports the vaults of the western porch (nw3 and sw3, Fig. 13).[36] Despite the complexity and asymmetry of these buttresses, the masonry courses between the inner and outer walls are seamless, indicating that they were designed and constructed as single units.

Although the irregular faces of the lower portal embrasures respond to the complex set of demands imposed by the vaults, jamb pedestals, and moldings, the basic dimensions of the piers were, once again, established by the simplest of all design procedures, the rotated square (Fig. 14).[37] The dimensions of the three principal faces of the buttresses were derived from a progression of inscribed squares, with a king's foot of .325m as the initial dimension (Fig. 15).

The clearest example of the use of geometry to determine structural sizing is found in the design of the transept staircase turrets (n2w, n2e, s2w, s2e). On each side of the north and south transepts is a complex mass of masonry that includes a polygonal staircase turret attached to diagonally set door jambs (Fig. 16). The interior chapel walls adjacent to the transepts on both the east and west become thicker, and the four lancet windows have been reduced to three. The increased thickness of the wall presumably was necessary to support the slender and vertical transept façade (a technique used at St.-Urbain, Troyes, a monument of scale identical to St.-Maclou). The staircase turrets were designed around pentagons, which also determined the thickness of the adjacent chapel walls (Fig. 17).

The sizing of the spur buttresses that reinforce the angles of the pentagonal staircases on the three exterior faces is also determined by the same method outlined by Master 2 in Villard de Honnecourt's portfolio of the second quarter of the thirteenth century. Among the drawings of geometrical schemes, devices, and templates, Master 2 provides a curious drawing with the inscription, "How to trace a five-corner tower." The odd rotation of this pentagon has recently been explained by Cord Meckseper, who demonstrated that a rotation angle of 18 degrees is created by using the marks on a mason's square.[38] At St.-Maclou, the difference between the two rotated pentagons at 18 degrees provides the exact width for the tower spur buttresses.

The tremendous flexibility of this procedure confirmed in the surviving German drawings makes it impossible to explain the design of the intricate transept masonry in a step-by-step analysis. The prescribed series of steps followed by Robin to design the complex scoops and beveled surfaces of the massive irregular masonry of the staircase turrets, portal jambs, and interior transept walls is not easily decipherable, but some fundamental relationships derived from inscribed squaring are evident and must have been similar to the schemes found on the west portal buttresses (Fig. 18).



11 St.-Maclou, Rouen, plan design scheme, radiating chapel (drawing: H. Shih and L. Neagley)

From Parchment to Site: Setting Out the Plan

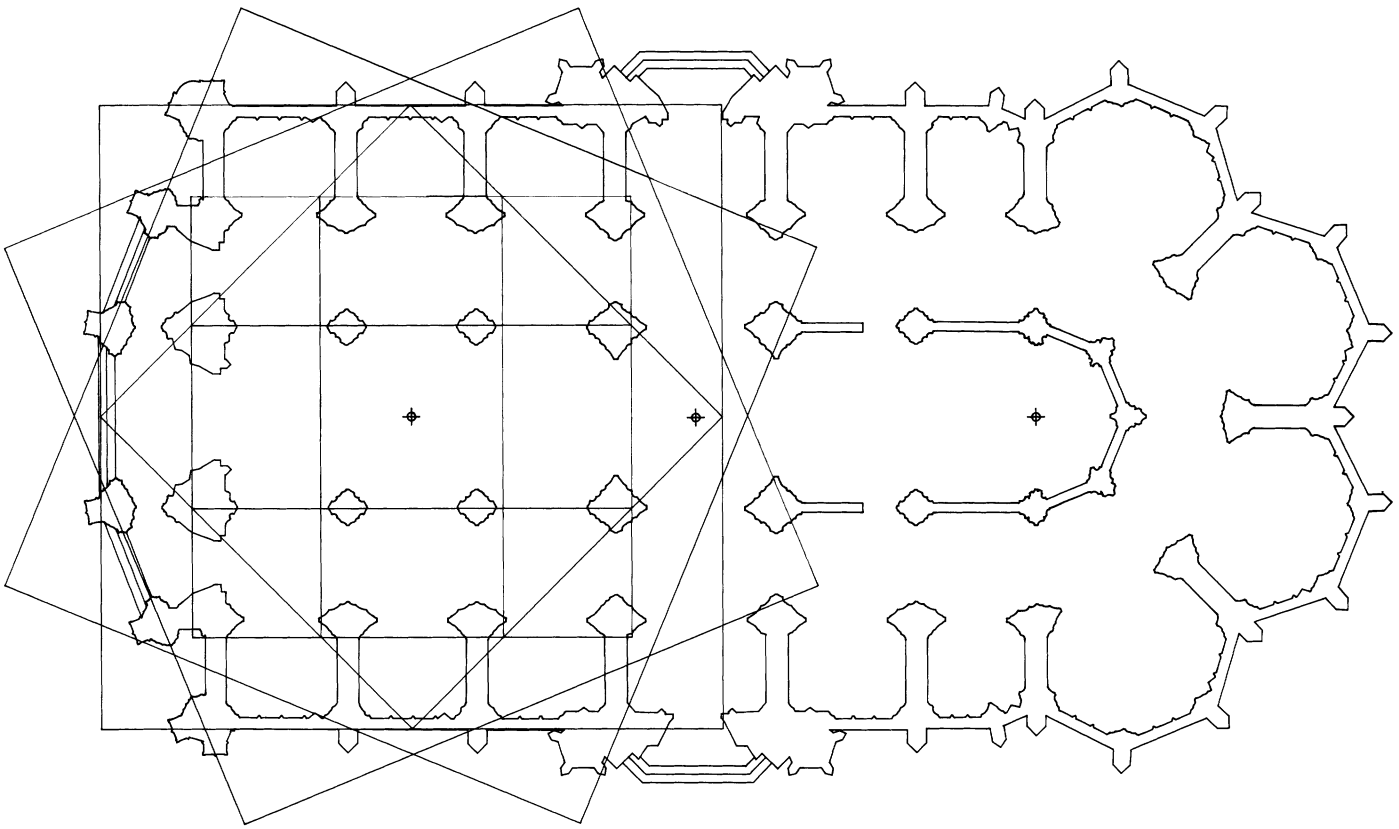
The geometric formulae suggested by an analysis of the new plan of St.-Maclou (and illustrated in Figs. 7, 10–12) should only be accepted if they provide the most efficient, practical, and economic blueprint for setting out the foundations for walls, piers, and buttresses at the site.[39] These design schemes also have an inherent progression of steps. Because

[36] The geometry of the interior piers is not discussed in this article. To understand fully the proportional relationships and dimensioning of the arcade, transept, and chapel-opening piers, cross-sections at several levels are necessary. The present survey deals with measurements only at the floor level relevant to the overall plan.

[37] The design center point is suggested by connecting the north-south and east-west faces (Fig. 17). Key dimensions were marked off at .975 m (to the face of the interior attached arcade pier), 1.415 m (to the door jamb of the north portal), and 1.977 m (to the door jamb of the central portal). While it is not surprising that these three principal faces are at right angles to each other, further analysis demonstrates that they are part of the same sequence of rotated squares (Fig. 16). The first square is based on .975 m and is exactly three *pieds du roi* or .325 m.

[38] C. Meckseper, "Uber die Fünfeckkonstruktion bei Villard de Honnecourt und im spateren Mittelalter," *Architectura*, I, 13, 1983, 31–40.

[39] This discussion is concerned with the procedure for marking the location of foundations. For the construction of foundations, see recent bibliography by S. Bonde and C. Maines, "The Archaeology of Monasticism: A Survey of Recent Work in France, 1970–1987," *Speculum*, LXIII, 4, Oct. 1988, 794–825.



12 St.-Maclou, Rouen, plan design scheme, western porch (drawing: H. Shih and L. Neagley)

certain measurements are dependent on others, the schemes imply a sequence of construction. Thus, the setting out of the plan suggested by the design scheme must also be confirmed by the chronology established through stylistic and documentary evidence.

Although no surviving plan drawings illustrate inscribed squares or grids, Bucher, Shelby, and others have suggested that the enigmatic schemes illustrating details of buildings were easily decoded by the mason who, through his training, learned to translate the drawing into a series of prescribed steps.[40] The complexity of the surviving drawings, the indisputable proportional relationships that guided the design of plans, and the extant German lodge books leave little doubt that such relationships existed, although no theoretical treatises have survived in Northern Europe dating to this period. There is no evidence to indicate the method used by masons to communicate the proportional relationships found in the plans of existing buildings. However, there are a number of possible ways to "construct" the design formulae suggested by Figs. 7, 10–12, and a logical and efficient procedure may be suggested.

The chronology of construction at St.-Maclou cannot be broken down into "campaigns" of construction since there are no changes in stylistic vocabulary or breaks in the masonry. On the other hand, a logical sequence of construction emerges from the written documentation and archaeological evidence.

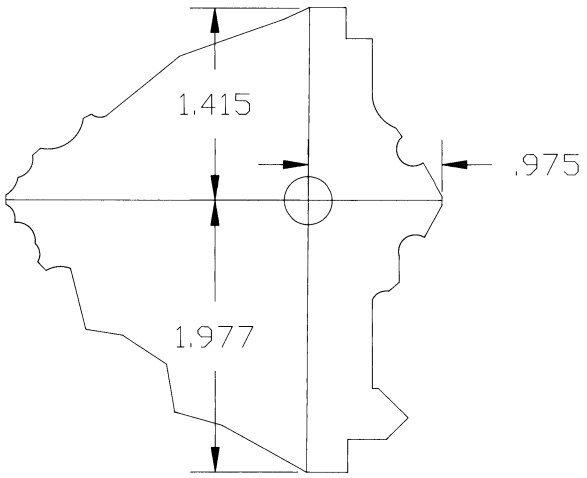
Although none of the earliest written sources are explicit concerning the origin of construction, three documents suggest that work began in the straight bays of the choir adjacent to the transept. The letter of indulgence granted by Archbishop Hughes d'Orgues and dated September 16, 1432 states that the thirteenth-century church was far too small for the growing parish and had recently collapsed in the transept area, so that immediate repairs were required.[41] The building accounts of 1436–37 specifically identify repairs being made to the roof of the old nave and new work undertaken in the chapel of Notre Dame.[42] This chapel

[40] Scholars have pointed out that the learned procedure by which medieval drawings were translated into stone constitutes the "secret of the medieval mason" and remained inaccessible to those outside of the tradition (e.g., Shelby, 47). This is confirmed in the well-known quotation from the Regensburg Ordinance of 1459, "If someone wants to undertake stonework with measure or an extrapolation device, which he does not know how to take out of the base plan, and he has not served as a workman nor enjoyed lodge promotion, then he should not in any way undertake the task. However, if one determines to undertake such, then no journeyman should stand by him or support his appointment"; Shelby, 47. While this statement seems to refer to taking elevations from a ground plan or how to interpret complex key plans or detailed drawings, its admonition might also apply to the setting out of a plan from a drawing.

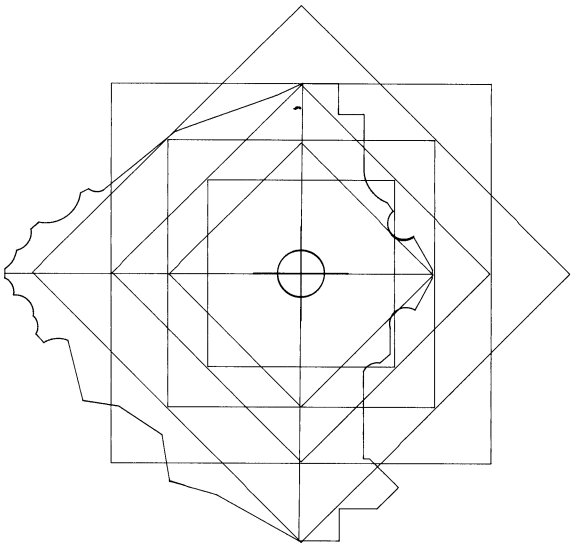
[41] Rouen, Archives départementales, Seine-Maritime, *Petit cartulaire*, G6872, fols. 54–55 and loose parchment, G7040.

[42] The fabric account entries for 1436–37 list considerable expenses for the construction of a new roof for the old nave. On December 25, 1436, "A Marquet Bataille pour quatre trefs et 8 souchevrons pour refaire la nef du parmy pour ice . . . 15 livres Tournois"; on January 20, 1437, "A Jehan Decessame carpentier pour avoir fait la carpenterie de la nef de moustier par marche fait a luy en un et tout . . . 22 livres"; and on March 10, 1437, "A Jehan de Soysons carpentier pour son tref de bessoingne tant pour la nef que pour autres chosez pour ice . . . 100 sous." Rouen, Archives départementales, Seine-Maritime, G6874.

13 St.-Maclou, Rouen, exterior western porch buttress, nw3 (photo: L. Neagley)



14 St.-Maclou, Rouen, cross-section of western porch buttress, nw3 (drawing: H. Shih and L. Neagley)



15 St.-Maclou, Rouen, design scheme of western porch buttress, nw3 (drawing: H. Shih and L. Neagley)

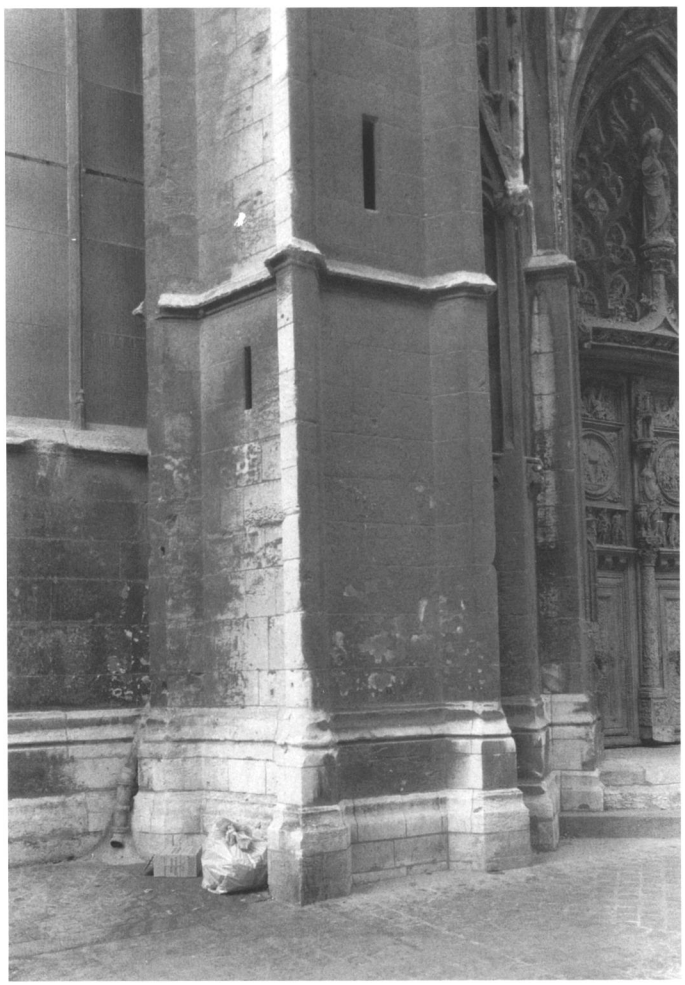
seems to be one of the chapels in the straight bays of the choir. A slightly earlier contract of 1434 made between Tassio Amiot and his wife, Guillotte, and the treasurers of St.-Maclou describes money provided by Amiot for a mass to be said in the chapel of Notre Dame that was "newly begun to be made."[43] Two years later the building accounts describe a payment to a mason for putting the beams (*estoiez*) against the tower and for supporting the four beams (*trefs*) of the chapel of Notre Dame.[44] Because the thirteenth-century nave was being roofed, the chapel of Notre Dame had to be in the choir, and, as the beams were being placed against an old tower, this chapel had to be adjacent to the old nave. This chapel was most probably situated on the north side and adjacent to the present transept (chapel NIIEI). Since the rue Martainville bordered the old church on the north side, expansion owing to the greater width of the new church had to be toward the south. This is verified by the reconstruction of the cemetery wall of the *petit aître* in 1458 and the request of Henry VI in 1448 for the donation of properties in the parish for the expansion of the nave.[45] Therefore, the beams of the new chapel of Notre Dame on the north side adjacent to the old transept could have been supported against the crossing tower of the old church, which was mentioned in the letter of indulgence of 1432.

This chronology is confirmed by a small detail in the design of the exterior wall buttresses. One exception to the

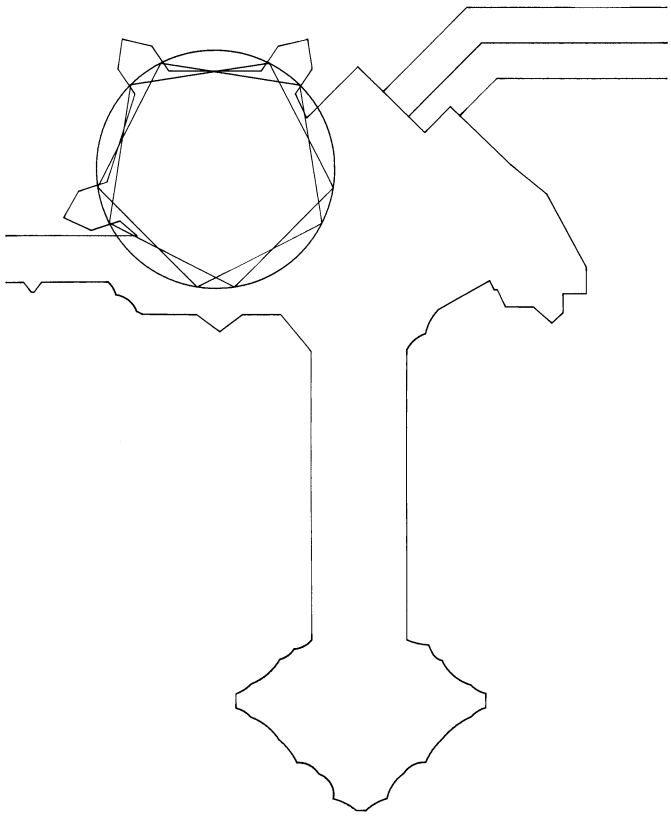
[43] *Ibid., Petit cartulaire,* G6872, fol. 30, dated October 19, 1434.

[44] *Ibid.,* fabric accounts for 1436–37, G.6874, twenty-six *sous* paid "A Jehan Le Fort, Jehan Gibes et Jehan Le Puost pour maistre des estoiez contre la tour et pour soustenir les quatre trefs de la chappelle notre dame pour chacun trois journees le jour 3 s. pour ice."

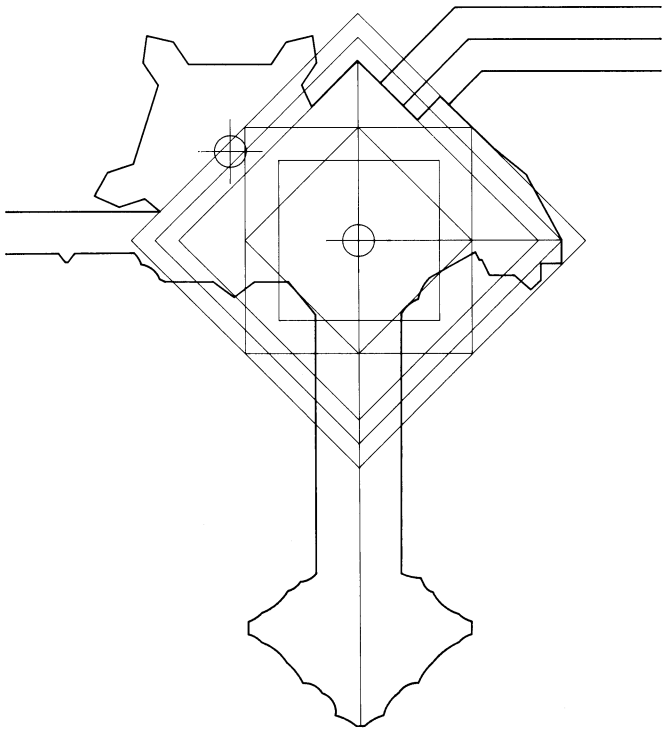
[45] *Ibid.,* loose parchment, G7040 (written February 6, 1447 and notarized July 29, 1448) and loose parchment, G7047 (dated May 27, 1458).



16 St.-Maclou, Rouen, exterior, north transept staircase turrets, n2e (photo: L. Neagley)



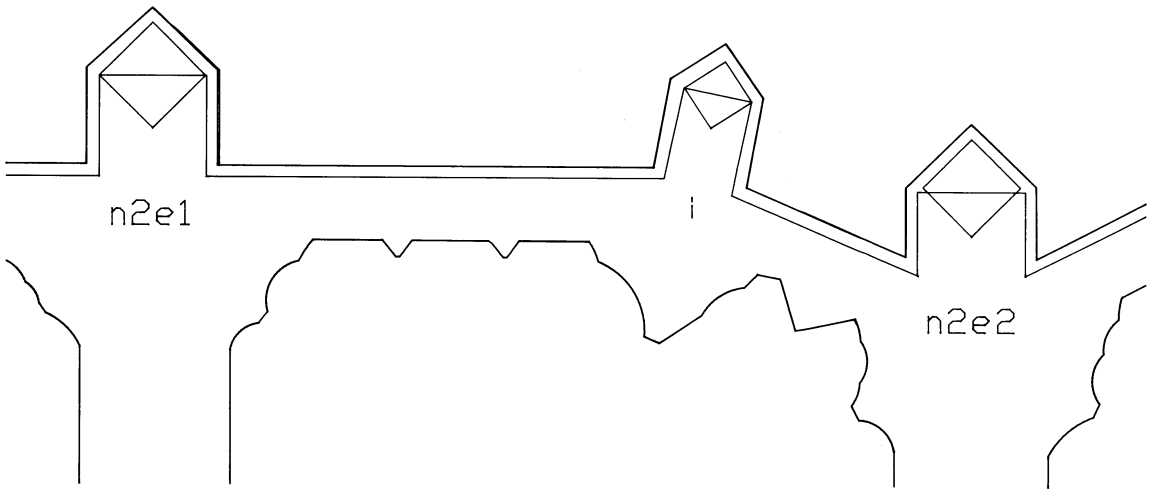
17 St.-Maclou, Rouen, plan detail of staircase n2w. Pentagon rotated 18 degrees, defines width of spur buttresses (drawing: H. Shih and L. Neagley)



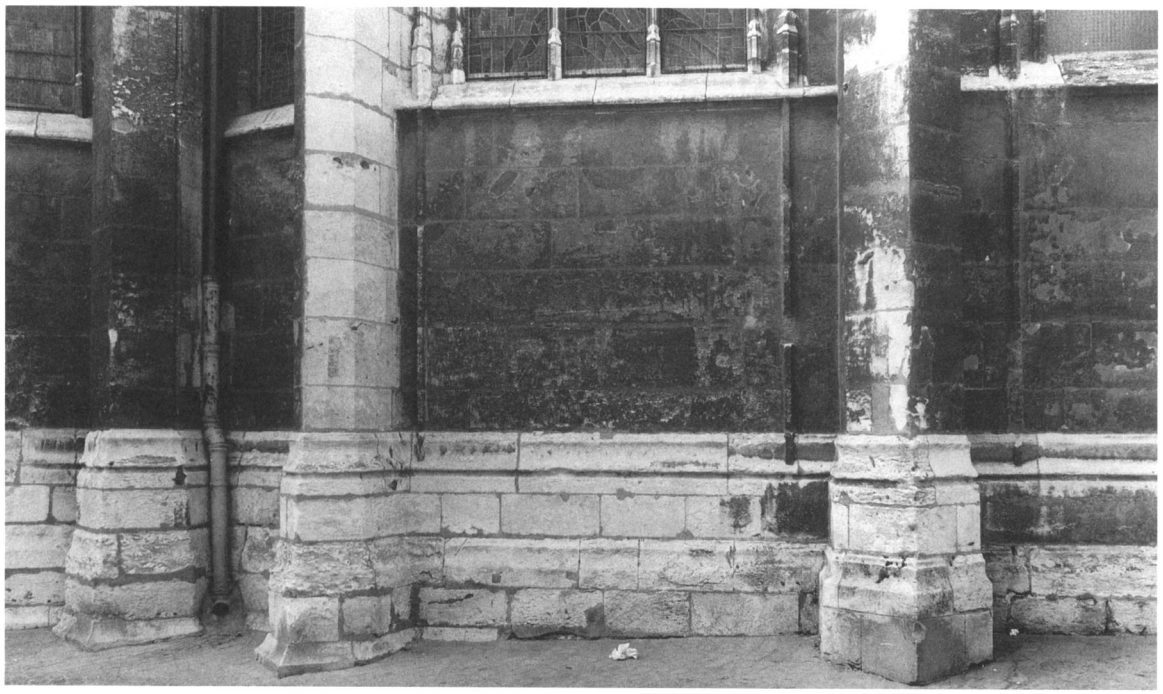
18 St.-Maclou, Rouen, plan detail of buttress adjacent to staircase n2w, design scheme (drawing: H. Shih and L. Neagley)

assiduous uniformity of style is a change in exterior buttress design that occurs in the straight bays of the choir (between buttresses i and n2e2 on the north and between buttresses x and s2e2 on the south). Pierre Robin's distinctive spur buttresses were designed around two squares, one inscribed inside the other and then projected so that the diagonal of the inner square is aligned with the front face of the larger square, thus creating a diagonally faced buttress. However, those buttresses attached to the choir straight bays have a simpler profile. Buttresses n2e1 and s2e1, as well as the small angled buttresses i and x, lack the sharp groove that separates the two squares at the corners present in all other exterior spur buttresses of the church (Figs. 19 and 20). Even the design of the wall buttresses of the same chapel NIIEII and SIIEII (buttresses n2e2 and s2e2) are of the more complex grooved type and are identical to all others found in the choir and nave. The simpler wall buttress design of the choir straight bay chapels only occurs at the lower level, while the grooved form emerges above the chapel roof. Thus, this seemingly minor detail indicates that chapels NIIEI, SIIEI, and parts of chapels NIIEII and SIIEII were laid out and constructed as a unit.

It is also likely that construction proceeded simultaneously or in close succession on both the north and south sides of the church. Despite the great variety of window tracery patterns at both the clerestory and chapel levels and the distinct designs of the piscinae niches in every chapel, a pattern on the north side always has its exact complement on the south side. This visual pairing of the window tracery and piscinae niches on the north and south sides suggests that they may have been constructed in close succession and that



19 St.-Maclou, Rouen, cross-section of exterior spur buttresses n2e1, i, and n2e2 (drawing: H. Shih and L. Neagley)



20 St.-Maclou, Rouen, exterior spur buttresses n2e1, i, and n2e2 (photo: L. Neagley)

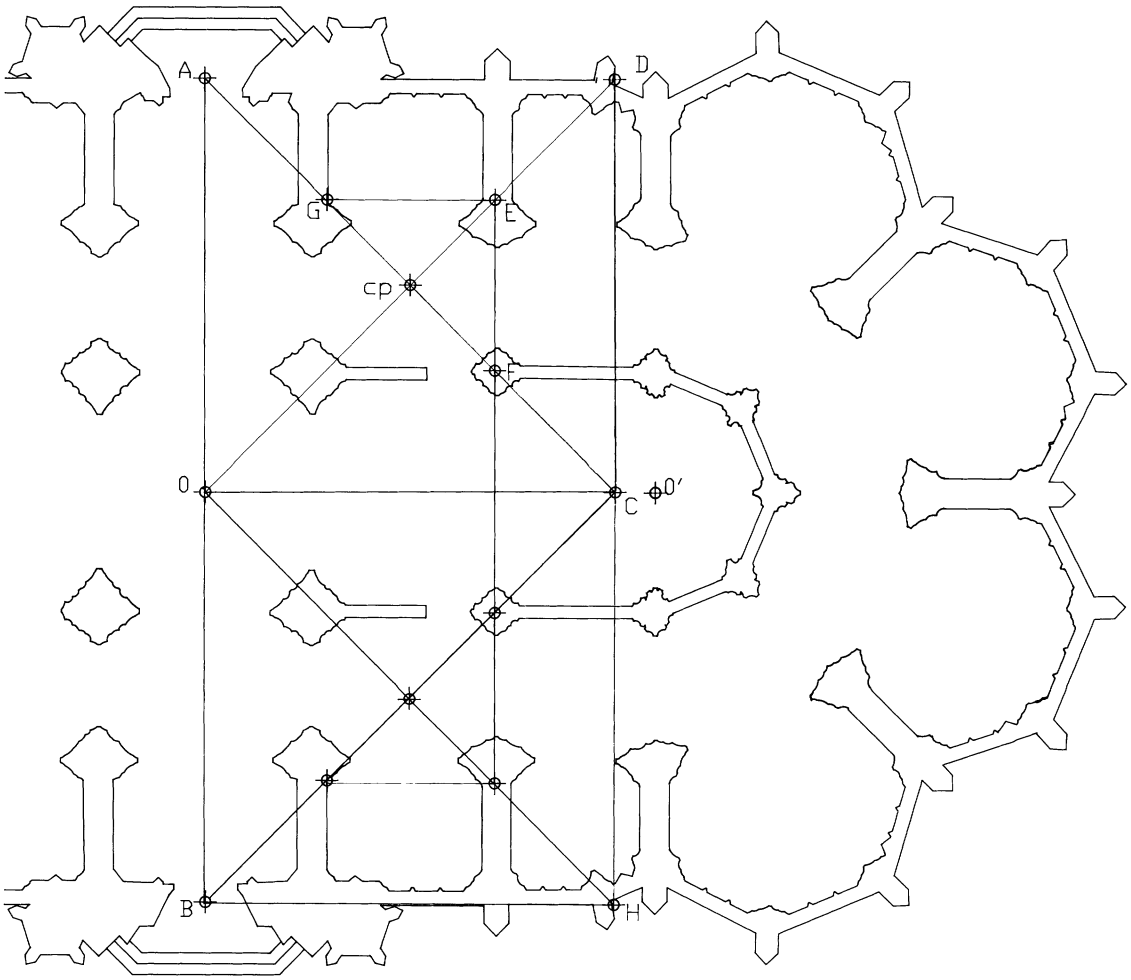
control over the diverse designs was exercised through the use of drawings. It therefore seems reasonable to assume that the four straight bay chapels of the choir (two on the north and two on the south) were the first to be constructed.

The design scheme suggested by Fig. 7 confirms this sequence of construction. To set out the transept, nave, and choir straight bays, the mason need only know an initial dimension (the width of the transept) and how to construct a right angle.[46] From this he would be able to establish all the key dimensions by using the intersection of arcs with diagonals.

The width of the new church was determined by the available land of the site, the desired size of the new church, and the location just to the east of the old thirteenth-century nave. Thus, *AB* equals the width of the church and the center of the transept *O* is identified (Fig. 21). Through a series of simple constructions using a cord and the intersection of arcs, the placement of the key points for the two straight bay chapels can be established.[47] These steps could be repeated on the south side, and at a later date, after the destruction of the thirteenth-century nave, the same procedure was used to lay out the nave bays adjacent to the transept. Inherent in

[46] Mathes Roriczer describes a different method for the construction of a right angle in his *Geometria deutsch* (see Shelby, 114–115). The method proposed here is described in Sebastian LeClerc, *Practical Geometry or a New and Easy Method of Treating the Art,* trans. from the French, London, 1727. Because of its simplicity, there is no reason to believe this method was not known in the 15th century.

[47] The procedure for setting out the choir straight bays may have been as follows: Point *C* is established at right angles to line *AB* and two squares, *OADC* and *OBHC* were set out. Creating the grid of bays was a simple procedure. Using points *O, A,* and *C,* arcs were swung to intersect with the diagonal of the square *OADC* and the placement of all the piers and walls was easily determined. The intersection of *OA* with diagonal *OD* located point *E;* the intersection of *CO* with diagonal *AC* located point *G;* and the intersection of *AO* with diagonal *AC* located point *F.* Thus, $OA = OC = OE$ and $AO = AD = AF$ and $CO = CD = CG$.



21 St.-Maclou, Rouen, plan detail setting out procedure of transept and choir straight bays (drawing: H. Shih and L. Neagley)

this constructive geometry are the geometric design schemes conveyed in Fig. 7. It is important to note that the chapel wall dividing the straight bays of the choir from the turning bays could not be laid out from the transept center *O*, a conclusion that is supported by the change in buttress profile, as previously discussed. These walls were established as part of the second setting-out sequence along with the radiating chapels from the hemicycle center *O'*.

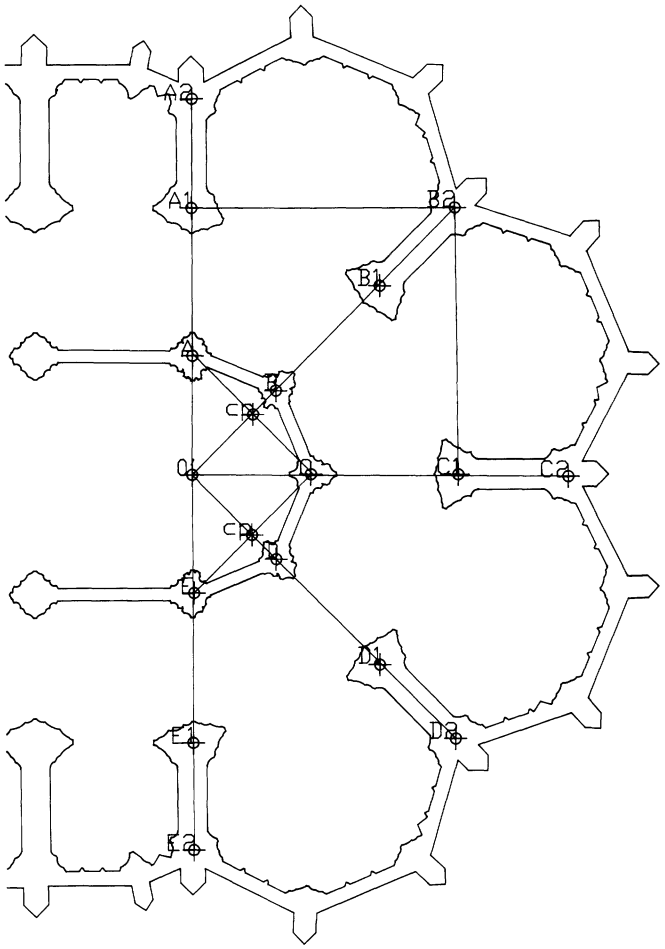
The most revealing evidence for the simplicity and elegance of the design and setting-out process of St.-Maclou is found in the turning bays of the choir. The width of the central vessel (*AE*) and the width of the aisles (*A'E'*) were established in the setting out of the transept (Fig. 22). A similar procedure was then followed for the layout of the choir, but instead of starting with the width of the entire church, the starting point was the width of the central vessel *AE* and its center at *O'*.[48] Once again, only a cord and the knowledge of the construction of a right angle were needed.

Thus, all points for establishing the four radiating chapels needed only to be constructed in one chapel, and then the other chapel walls and buttresses could be more easily set out by marking the same distances along the remaining radials. With only slight variations, this recalls the sequence of steps used to lay out the straight bays of the choir from the center of the transept.

The exterior walls of the radiating chapels were designed around center points within each chapel, *O3* (Fig. 23). Thus, the western half of the chapel is designed around an octagon resulting from geometry generated from the hemicycle *O'*, and the eastern half of the chapel is designed around a hexagon resulting from geometry generated from *O3*.[49] This design beautifully illustrates the mannered "cerebral games"

[48] The procedure for setting out the hemicycle piers and radiating chapels may have been as follows: a right angle was constructed at *O'* to establish *C* at the same distance as *O'A* and *O'E*. The center point (cp) of lines *AC* and *CE* was found and *O'B* and *O'D* were marked off on radials passing from *O'* through these center points at the same distance from *O'* as *O'A*, *O'C*, and *O'E*. Since the length of *O'A'* was known from the transept, then *O'B*, O'C, and *O'D* were marked off along the same radials. *B2* is established by the intersection of arcs swung from *C'O'* and *A'O'*. *C2*, *D2*, and *E2* are marked off at the same distance along the radials from *O'* and *O'B2*.

[49] The procedure for setting out the exterior walls of the radiating chapels may have been as follows: using the center point *O3* as the design center, half the distance of the diagonal *B2C2* established *F* and *G* by intersecting arcs *B2O3* and *O3B2* to create *F* and *C2O3* to create *G*. The depth of the chapel to the outside wall is equal to the width of the chapel opening (*B'C'*) that was established from *O'*, and therefore the chapel is designed around a square. Caroline Bruzelius has also shown that the width and depth of the chapels of the 13th-century Cistercian church at Longpont were based on 4.50 m squares ("Cistercian High Gothic: The Abbey Church of Longpont and the Architecture of the Cistercians in the Early Thirteenth Century," *Analecta Cisterciensia*, XXXV, 1979, 48).



22 St.-Maclou, Rouen, plan detail setting out procedure of eastern end (drawing: H. Shih and L. Neagley)

that masons often played, as evinced by surviving fifteenth-century German drawings.[50]

The design scheme (Fig. 12) suggests that the polygonality of the porch was established by the 22.5-degree rotation of a square based on the width of the church. However, there is no evidence that masons used degrees in setting out points on the ground. On the other hand, the diagonal planes of the porch were easily laid out by a slight variation of the procedure used for the transept and choir (Fig. 24). The dimensions of the nave bays were determined by the transept module. A point (*O2*) was located in the middle of the central nave bay. This is the same point that determined the length of the nave and porch as suggested by Fig. 9. Then, following a procedure of constructive geometry, the key angles and placement of buttresses were established.[51]

The setting-out steps suggested here for St.-Maclou demonstrate the same geometric principles outlined in the German lodge books of the fifteenth century; no calculations were necessary to achieve precision; geometric forms are generated from three center points; and through the repetition of simple procedures involving the construction of right angles, extension of radials, and intersection of arcs, variations in the plan design of the transept, choir, nave, and porch are achieved. The only tool needed to set out the plan was a cord. In light of the accuracy of the dimensions at St.-Maclou, this cord was undoubtedly recalibrated at frequent intervals against a fixed measurement possibly marked off in the mason's lodge in the *petit aître* or established in the early phases of the setting-out procedure.

Whether or not the drawing that Pierre Robin gave to the treasurers in 1437 displayed the elaborate sequences of rotated squares as illustrated in Figs. 7, 10–12 will never be known. However, the proportional relationships established by progressive squaring for the plan were communicated in one way or another to the *appareilleurs* and masons who set out the foundations for the church following procedures suggested by Figs. 21–24.

In addition to providing a clear picture of the geometric schemes of the transept, choir, and western end, the new plan established in the 1988 survey offered a radically different picture of the structural system at St.-Maclou. The 1899 plan by Vincent erroneously indicates that the exterior walls and the walls dividing the chapels are of equal dimensions. Rather, the walls dividing the interior chapels are approximately twice the thickness of the exterior wall of the chapels (compare Figs. 1 and 2).[52] In addition, although the arcade piers are still relatively slight, the piers at the chapel openings are massive. Thus the structure of the building is dependent on a radial armature consisting of the interior chapel dividing walls and their attached piers.

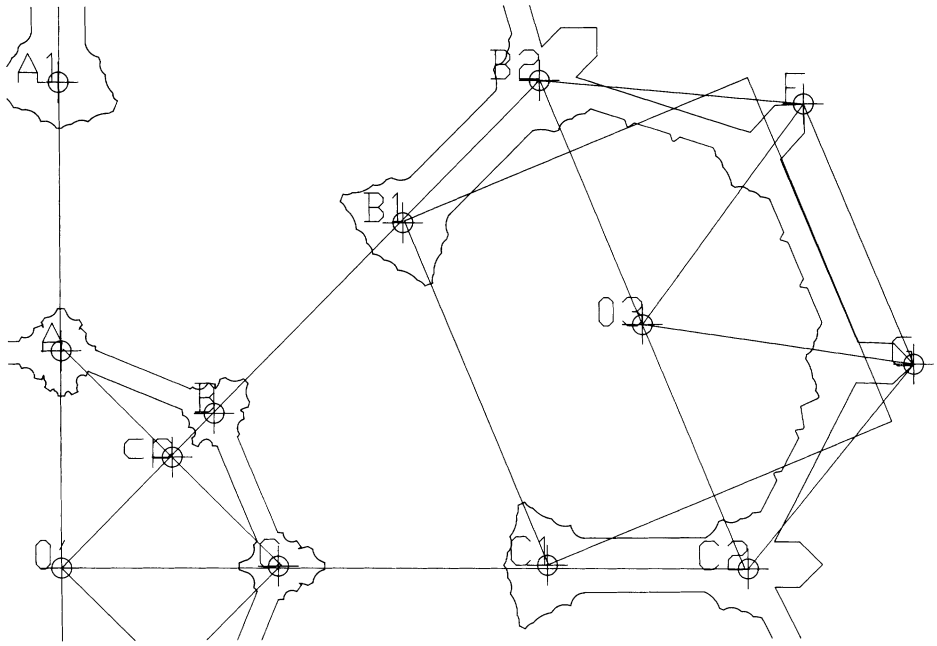
The unmitigated vertical space of St.-Maclou is framed by sharp, prismatic, continuous moldings of the arcade piers and wall shafts. The average nave pier has a diameter of 1.510m (north-south) × 1.630m (east-west) at floor level, with a bay span of 6.034m in the central vessel. Thus the ratio of pier to span is 1:3.996 (or 1:4, Fig. 5).[53] While the basic precept of interior Northern French Gothic space had been the creation of a weightless, vertical, and light-filled interior through the development of a skeletal system of structure, Pierre Robin also extended this illusion to the exterior. He

[50] F. Bucher describes Late Gothic drawings as concentrating on the "perfection of details and cerebral geometric games" (review of H. Koepf, *Die gotische Planrisse,* in *The Art Bulletin,* LIII, 1, 1971, 113–115).

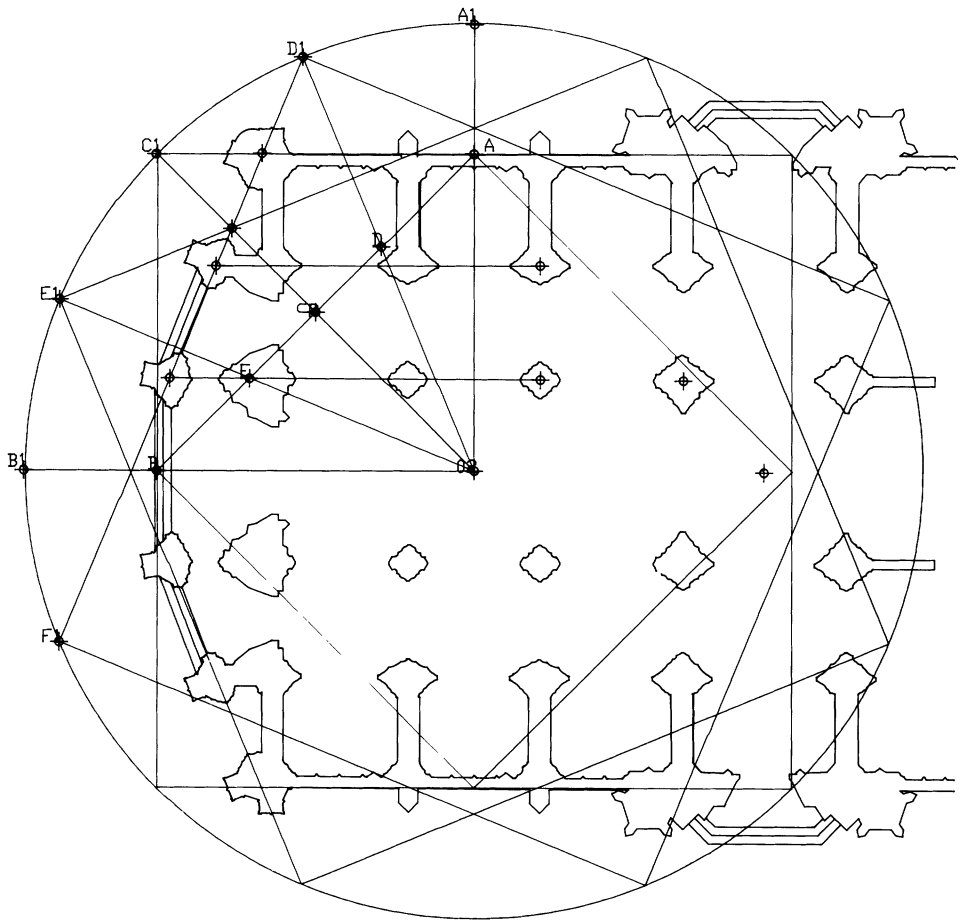
[51] The procedure for setting out the western porch may have been as follows: *O2A* is already established and *O2B* is marked off at the same distance along the axis established in the transept. The center point (cp) of diagonal *AB* is found and the point *E* is marked off where arc *AO2* intersects with diagonal *AB* Point *D* is located where arc *BO2* intersects with the diagonal *AB*. The distance from *O2* to *A'*, *D'*, *C'*, *E'*, and *B'* is taken from the transept (it is equal to the side of the transept macro module, or 18.474 m). This distance is marked off along these radials, the procedure is repeated on the south side, and then the point on the north (*D'*) is connected to the corresponding point on the south (*F'*) forming the plane for the northern porch buttresses. The placement of the buttresses along these plane lines is determined by the position of the interior arcade piers and chapel-opening piers whose east-west axes are continued to the exterior.

[52] The interior walls dividing the chapels at floor level average .930 m, while the exterior walls at the level of the interior floor have an average thickness of .442 m.

[53] In a building of comparable scale such as St.-Urbain in Troyes, the nave pier dimensions (pier C, for example) are 2.66 m (north-south) × 2.54 m (east-west) with a bay span of 8.4 m; thus, the ratio of pier diameter to bay span is 1:3.2. See M.T. Davis, "On the Threshold of the Flamboyant: The Second Campaign of Construction of Saint-Urbain, Troyes," *Speculum,* LIX, Oct. 1984, 874.

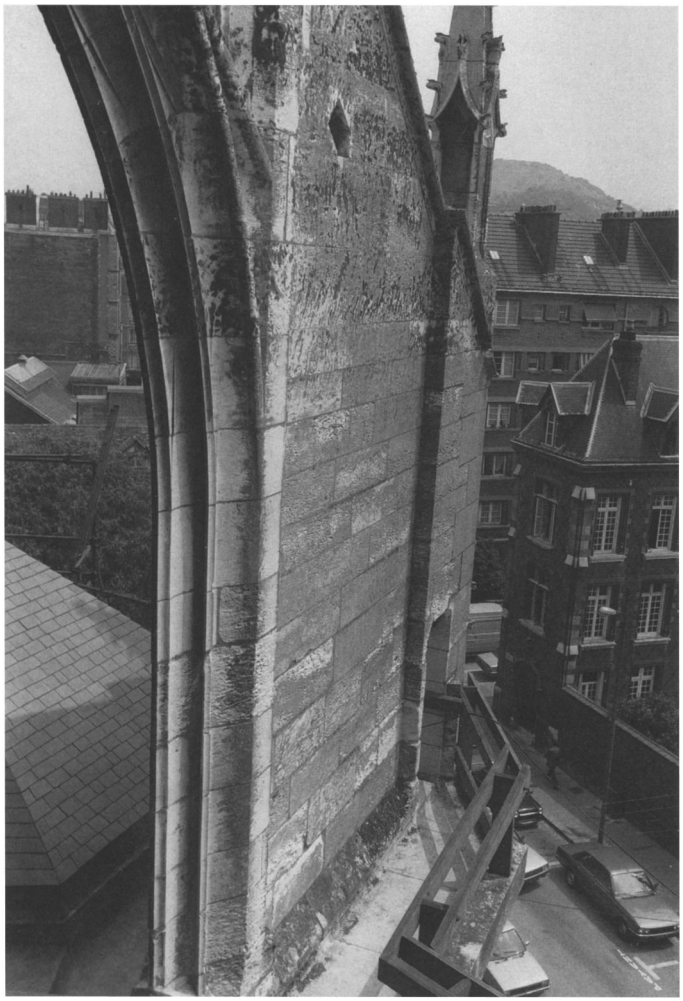


23 St.-Maclou, Rouen, plan detail setting out procedure of radiating chapel (drawing: H. Shih and L. Neagley)



24 St.-Maclou, Rouen, plan detail setting out procedure of western porch (drawing: H. Shih and L. Neagley)

accomplished this by using several means to disguise the true structure. The walls dividing the chapels are .930m, but as they extend to the exterior and become visible as thin spur buttresses, they are reduced by several centimeters and thus create an illusion of even greater fragility. Reduction also occurs above the drip molding, where the chapel walls extend above their roofs and form wafer-thin *culées* composed of a single thickness of stone supporting stick-like flying buttresses (Fig. 25). To stabilize and strengthen these walls and to increase their function as buttresses for the central vessel, Robin added reinforcing arches (or interior flying buttresses) below the roofs and above the aisle vaults that connect the central vessel with the *culées* (Fig. 26). Robin understood the radial armature of the interior chapel walls



25 St.-Maclou, Rouen, exterior buttress *culée,* choir s1a1-s2a2 (photo: L. Neagley)

and piers, concealed both from the exterior and the interior of the church, to be the true structural support of the church. The great bulk of the massive, lozenge-shaped chapel-opening piers is disguised by the sharply prismatic moldings. In the central nave chapels, these piers average 2.463m (east-west) in diameter, while the chapel opening of the same chapel is 2.961m; thus, the ratio of pier to opening is 1:1.2. Few Gothic buildings have such massive supports, yet few provide such an illusion of weightlessness. This new disguised support system illustrates structural invention, motivated by a new concern for spatial illusionism, that is continued into the Late Gothic period.[54]

Robin's concern for stability may also be reflected in the absence of a glazed triforium and the presence of a choir

26 St.-Maclou, Rouen, interior buttress, above nave aisle (photo: L. Neagley)

screen. The blind triforium provides additional support for the thin walls, and the choir screen helped to stabilize the exceedingly thin hemicycle piers. Although the choir *clôture* and *jubé* were destroyed in the religious wars of the late sixteenth century, it is clear that they were designed by Pierre Robin, since small bases of the screen shafts are embedded within the mass of the arcade piers.

Conclusions: Pierre Robin, the Plan Design of St.-Maclou, and Late Gothic Architecture in France

Although the histories of individual monuments are unique, the dynamic reappraisal of Gothic architecture in the fifteenth century that gave rise to Robin's *flamboyante* style is the result of the tension created by opposing forces: progressive developments that arose from the extreme sophistication and technical proficiency in the craft of masonry versus nostalgic and retrospective tendencies that resulted from the social and economic upheavals in the last decades of the English occupation of Normandy. These two tendencies mingled in the formation of the aesthetic tastes of both the patron and craftsman. Patronal artisanal values were fostered in the cloth industry centered in the parish of St.-Maclou. At the same time, the craft of masonry in the city of Rouen was concentrated in the same parish by masons whose confraternity was at St.-Maclou and who must have viewed the church as their "masterwork."[55] The architecture is the consummate expression of the discipline provided by the High Gothic canon, a canon made exuberant by the extravagance of the Late Gothic building craft. These material values led to a new priority given the virtuosity of craftsmanship and contribute to the unique character of the plan

[54] Sergio Sanabria demonstrates the inventiveness of the Late Gothic architect in the 16th century in the treatises of Rodrigo Gil de Hontañón as expressed in the development of structural formulae ("The Mechanization of Design in the 16th Century: The Structural Formulae of Rodrigo Gil de Hontañón," *Journal of the Society of Architectural Historians,* XLI, 4, 1982, 281–293; see also R. Mark and W. Clark, "Structural Experimentation in Gothic Architecture," *Scientific American,* CCXI, 5, Nov. 1984, 176–185). Structural precociousness did not end with the 13th century. In many respects, the extreme illusion of weightlessness of St.-Maclou is a natural culmination of the implications of the skeletal system inherent in Gothic architecture.

[55] Taillepied's history of Rouen of 1588 (*Recueil des antiquitez et singularitez de la ville de Rouen,* Rouen) mentions a masons' confraternity of Sts. Simeon and Jude in the church of St.-Maclou. A chapel with this dedication is identified in a bequest of August 19, 1487 of Collette Masselin, "icele veufve promist faire faire et payer a ses despens le pavement et alle de endroict la chapelle Sainct Symon Sainct Jude" (Rouen, Archives départementales, Seine-Inférieure, *Grand cartulaire,* G6873). The fabric account of 1443–46 also mentions a burial in the chapel of St. Jude, "corps entrez a leglise la chapelle fait pour Saint Jude 30 sous" (Rouen, Archives départementales, Seine-Inférieure, G6847).

design of St.-Maclou. Great importance was placed on the development of an expedient geometry in the design and setting-out process of construction. This expediency was necessary because the master mason was absent from the site. Pierre Robin, it seems, never intended to direct the construction. He arrived with Oudin de Mantes, who stayed on as master mason after Robin's departure in 1437. Simon Le Noir, who was also present at this time, took over as master mason in the 1440s. Work was carried out exclusively by master masons, who functioned primarily as contractors, executing with great accuracy the detailed drawings provided by Robin. While methods and procedures of Late Gothic plan design are rooted in the building practices of the thirteenth century, they were transformed in the fifteenth century through an increasing specialization within the workshop, which allowed for a division of labor among master masons, *appareilleurs*, and architectural draftsmen, as well as greater freedom and individuality in design solutions.

Whereas the use of geometry during the thirteenth century provided the organizational vehicle for the design of plans and figural arts, as demonstrated by Villard, by the fifteenth century the basic tool of the mason became the actual subject of design. Perhaps the most explicit example of this shift in priority is represented by the design of Gothic keystones or spandrel decoration. Pierre Robin transformed the foliate and figural keystones of Rouen Cathedral and the abbey of St.-Ouen into elegant discs of abstract geometric patterns. The master mason of the axial chapel of the cathedral of Lisieux, constructed around 1432, inserted lithic geometric exercises into the spandrels, so that the dado wall reads like a mason's sketchbook. Thus, the unusual design features of the plan of St.-Maclou—the axial pier, the polygonal porch, the geometric relationship of bays, and the central planned basilica—make directly explicit the underlying abstract design process of the master mason.

It is likely that complementary geometric formulae used in the plan design were also extended to the design of vault height and elevation proportions. It seems that only rarely, as in the case of Milan Cathedral, did building progress without an initial determination of vault height.[56] Recent studies have shown that thirteenth-century elevations of the cathedrals of Amiens and Beauvais, and the abbeys of St.-Denis and Longpont were determined *ad quadratum*, whereas the cathedral of Bourges, possibly the abbey of St.-Ouen, and the parish church of St.-Germain at Argentan were designed *ad triangulum*.[57] Using the macro module as the base line, if Pierre Robin calculated the vault height based on a triangle, the vaults should be 22.625m from the pavement, and if he used a square, the vaults should be 26.126m. The vault heights published by Loth (22.8m) and Ouin-Lacroix (25m) differ too widely to permit any conclusions. The role of the transept macro module in the design of the vertical measurements of St.-Maclou must therefore await a new, precise survey before any claims can be made.[58]

Although it is tempting to explain the presence of the axial pier at St.-Maclou as an iconographic feature or as the result of the impact of German and Central European architecture in Rouen, it must also be linked to the desire of the architect to provide a design that could easily be executed in his absence. Axial piers existed in some flat-ended Cistercian churches of the twelfth century (Dol-de-Bretagne, for example), and Villard's drawing of an ideal Cistercian church includes an axial pier, but St.-Maclou's plan is not related to this tradition. In fact, the axial pier is extremely rare in French architecture before the second quarter of the fifteenth century. Linear clarity and diagonal recession evident in the pier and buttress design are distinct characteristics of Pierre Robin's style. The axial pier and absence of an axial chapel provide both.

What little we know about Pierre Robin suggests that he was a well-known draftsman. The earliest record of his name is found in the 1412 accounts of the confraternity of St.-Yves for their chapel in Paris. In February of that year, the master of the works, Benoit de Savoye, presented a drawing of the portal made by Pierre Robin to the patrons of the confraternity.[59] This reference has two similarities to his documentation at St.-Maclou. First, in the building accounts of both St.-Maclou and St.-Yves, Robin's name only appears once, in reference to payment for drawings, and, secondly, although he was a master himself, the workshops at both churches were under the direction of other master masons. His name again appears in a reference to drawings of funeral procession canopies that were to cover the body of King Charles VI when it was displayed in the choirs of the cathedral of Notre-Dame in Paris and the abbey of St.-Denis.[60] The processional litter used to transport the king's coffin from the Hôtel St.-Pol to the cathedral was also executed after plans by Robin.[61] The pristine polygonality of the plan of St.-Maclou draws attention to the underlying geometric

[56] J. Ackerman, " '*Ars sine scientia nihil est*': Gothic Theory of Architecture at the Cathederal of Milan," *Art Bulletin* XXX, 1, 1949, 89.

[57] For Amiens, see Murray, 61, for Beauvais, see Murray and Addiss, 540; for Longpont, see Bruzelius (as in n. 49), 49; for St.-Denis, see Bruzelius (as in n. 31), 80.

[58] J. Loth, *Saint-Maclou de Rouen*, Rouen, 1913, 17; C. Ouin-Lacroix, *Histoire de l'église et de la paroisse de Saint-Maclou*, Rouen, 1846, 15. This discrepancy is significant and dramatically underscores the need for precise and consistent dimensions.

[59] The connection of the Pierre Robin responsible for St.-Maclou and the Pierre Robin identified with work in Paris clarifies my earlier position (Neagley, 377). A new document was brought to my attention by Professor Anne Prache. In a recent dissertation, "L'Architecture civile et religieuse à Paris sous la régne de Charles VI," *Thèse de 3e cycle*, University of Paris, Sorbonne, 1987, 349–351, I. Taveau cites a document that establishes a positive connection between the Pierre Robin of Paris and the Pierre Robin of St.-Maclou. The document records a payment to Pierre Robin at St.-Yves in Paris, ("Pour le parchemen et pourtraiture du portail de l' église que Pierre Robin avoit fait—LXXII s.," Arch. Nat. LL 963 B, fol. 76). This citation alone would not be enough to confirm the identify of the St.-Maclou Robin if it were not for the presence of another mason. René Couffon lists three other masons working on St.-Yves at this time (see "La Chapelle Saint-Yves, à Paris," *Bulletin monumental*, XCIII, 1934, 358–359). Although he does not mention Robin, he identifies Simon Le Noir, along with Jean James and Geoffroy Sevestre. Both Simon Le Noir and Pierre Robin are listed together in the 1436–37 accounts at St.-Maclou. These masons, then, seem to be connected in Paris as well as Rouen.

[60] B. Prost, "Mélanges artistiques," *Archives Historiques. Artistiques et littéraires*, I, 1889, 212–216.

[61] Taveau (as in n. 59), 350, cites Y. Grandeau, "La Mort et les obsèques de Charles VI," *Bulletin philologique et historique du Comité des travaux historiques et scientifiques*, 1970, 150–186.

framework of the design. Even though the resulting plan design was unorthodox and bold, he still worked within the conventions of the craft. The permission to plant an idiosyncratic axial pier in the center of the hemicycle was most probably granted by the venerable cathedral of Paris, where he had served as master mason before coming to Rouen. The axial pier in the ambulatory of Notre-Dame also visually bisected the longitudinal space of the central vessel, an effect that intrigued other Late Gothic Parisian architects, such as the anonymous master of the choir of St.-Séverin.[62]

By the mid-thirteenth century, hemicycle design was changing from semicircular to polygonal. Inspired by Jean d'Orbais's plan of Reims Cathedral, Hugues Libergier created at St.-Nicaise a hemicycle plan based on an octagon with five radiating chapels, a formula repeated at another royal Benedictine abbey in the early fourteenth century, St.-Ouen in Rouen.[63] As long as there remained an odd number of radiating chapels, setting out the east end was a complex, intuitive, and often imprecise procedure. Hemicycle keystones (and hence the design centers) were pushed to the east of the transverse arch; small irregular chapels were created to join the turning bays to the straight bays, and trapezoidal bays were formed in the aisles at this juncture. With the flat side of the hemicycle octagon toward the east, there is no way to divide it symmetrically so that each turning bay and contiguous chapel is identical. St.-Maclou is the first Gothic church that has a completely regular chevet with identical ambulatory bays and radiating chapels. Pierre Robin was willing to sacrifice tradition in order to achieve precision, a pristine regularity, and expedient design. A number of other churches in Normandy, such as St.-Paul at Le Neubourg, Notre-Dame at Caudebec-en-Caux, St.-Pierre at Caen, and St.-Germain at Argentan, adopted the axial pier but negated the benefits of perfect symmetry by retaining the axial chapel. But the more pronounced and streamlined polygonality of Late Gothic hemicycles and choirs stems from the transparent geometry of their design.

This analysis indicates that earlier notions of the attribution and chronology of the polygonal porch must be revised. Paul Frankl suggested that although Pierre Robin drew up the plans for the entire church in the 1430s, Ambroise Harel, who is documented as master mason between 1467 and 1480, redesigned the west façade and western porch.[64] Because the overall length of the nave and western porch was determined by the transept macro module and because the plan design of the porch is merely a variation of the same theme expressed in the choir, it was surely designed by Pierre Robin in the second quarter of the fifteenth century, although construction had not reached the western end until the 1470s. Ambroise Harel, like the other masters identified in the building accounts, functioned primarily as a building contractor, carrying out the plans by Robin. The west façade porch, inspired by the cathedral of Rouen, provided an elegant structural solution to support the thin western façade wall, and served in a variety of both liturgical and secular functions. Yet the unique shape is linked to Robin's design methods and his desire to complement the east end formally.[65]

In light of this analysis, the unequal-size bays gain new meaning. Bays in this Late Gothic building are not self-contained, independent units added to one another but imperceptibly linked to the whole. Generated from a common design center, the bays are spatially integrated through diagonality. Thus diagonality is not only conveyed by the ribbed vault and diagonally set capitals and bases, as in Early and High Gothic architecture, but is also applied to the relationship of bays, of parts to the whole, of mass and space. Diagonality resonates at St.-Maclou in every aspect of Pierre Robin's design—the axial pier, the polygonal porch, the diagonally faced buttresses, the pier design of flat-nosed fillet moldings, and the fundamental integration of mass and space through geometry.

The analysis presented here also underscores the connection of Late Gothic design with that of the thirteenth-century cathedrals. The complexity of the plans of High Gothic cathedrals suggests that the designers relied on a combination of different geometric schemes based on arcs and intersections for the construction of chevets and an arithmetic process based on combining identical bays of regular dimensions to form the length of the nave. Although there are relatively few comparable studies, there does seem to be a desire for nave bay uniformity. At Amiens, the five center nave bays are identical units, while the eastern and western-most nave bays provide transitional spaces to the transept and western entrance.[66] In fact, the design of St.-Maclou may reflect the same philosophy, but because there are only three nave bays, with the eastern and western bays serving as transitional bays, there are no repeated dimensions.

This analysis also reveals the transept, given visual focus by the towering lantern, to be the generative design center. By placing the transept crossing midway between the nave and choir and by the complementary polygonality that directed movement from the east and west end, Pierre Robin made explicit both the visual and design center. In his discussion of "visual logic," Panofsky wrote that "membrification of the edifice permitted him [the viewer] to reexperience the very processes of architectural composition."[67] Panofsky was referring to the articulation of the wall surface of an elevation and pier forms that made explicit the implied lines of force of the ribbed vault. The same connection between the process of

[62] The choir plan of St.-Severin in Paris was based on the cathedral of Paris and was constructed by an unknown architect after 1489. See J. Verrier, "L'Eglise Saint-Séverin," *Congrès archéologique de France,* CIV, 1946, 136–162.

[63] Jean d'Orbais's choir at Reims Cathedral also uses a five-part hemicycle, with the design centerpoint linked to the last straight bay of the choir. Narrow rectangular chapels result that join the turning bays and straight bays.

[64] Frankl (as in n. 3), 201. The attribution of the western porch design to Harel is frequently repeated because of the similarity of the polygonal porch of St.-Maclou to the porch at St.-Vincent in Rouen (destroyed in 1944) that was constructed by Harel around 1480 (R. Herval, *Saint-Maclou de Rouen,* Rouen, 1933, 52).

[65] I discuss the relationship of the western porch of St.-Maclou with the one intended for or partially constructed at the cathedral of Rouen by Jean Perier (pp. 385–386).

[66] Murray and Addiss, 47.

[67] E. Panofsky, *Gothic Architecture and Scholasticism,* New York and Cleveland, 1957, 59.

design and the spatial experience also applies to Pierre Robin's transept.

The identification of the transept as the seminal design center reestablishes a link between Late Gothic architecture and Carolingian and Cistercian plan design. In the case of St.-Maclou, the first two straight bays of the choir were constructed in the initial stages of building, but their dimensions and placement were determined by a transept geometry. This lack of an obvious connection between the design center and the earliest phases of construction may have obscured the identification of a coherent design system in High Gothic cathedrals. Only recently, Murray and Addiss have concluded that the great square of the transept at Amiens (the crossing and adjacent bays) was used to establish the overall length of the choir and nave.[68] The suggestion of a uniform "Gothic" system of plan design must remain entirely speculative until further studies are undertaken, but the remarkable similarities between the plan design relationships of such disparate monuments as St.-Maclou, St.-Urbain in Troyes, and Amiens Cathedral suggest that such a system or theory of plan design may have existed.

A second notion concerning the design of Gothic monuments must, however, be challenged. The present plan, arrived at by combining precise survey techniques and the analytic power of computer drafting, provides greater precision than can be obtained from hand drafting methods, especially for dimensions that cannot be directly measured, such as wall, buttress, and pier thicknesses. Since every measurement was confirmed with an independent check, dimensions retrieved from the computer plan can be stated with great confidence. It is, therefore, surprising that evidence is lacking of a "foot" being used in places where one might expect to find it. Scholars have frequently claimed to discover the basic unit of measure used in the layout of churches. Prak discovered the *pied de roi* (.324m or .325m) at Amiens Cathedral; James found the Roman foot of .295m at the Ste.-Chapelle in Paris; and Walsh proved the Roman foot was used in the plans of the Cistercian abbeys of Bordesley, Fountains, and Kirkstall.[69] Steinke demonstrated that the Roman foot was used in the nave of Notre-Dame in Caudebec-en-Caux in the early fifteenth century, while the king's foot of .324m was used in the choir fifty years later when the church was under the influence of the work at St.-Maclou.[70] Documentation, especially in the form of contracts between patrons and masons, also suggests that overall measurements that determined the size and shape of the structure were sometimes stipulated.[71] In a contemporary contract of 1402 between the mason Thomassin Gaignet and the patron Robert Alorge for the construction of a chapel of the Cordeliers in Rouen, Alorges specified the dimensions of the chapel in *toise* followed by the phrase *au environ* indicating that these were not exact dimensions. He also described markers at the site, indicating that the chapel, more importantly, should fit between the rue du Vieil-Pont, the king's street, and the fountain.[72]

The fabric accounts of St.-Maclou frequently mention units such as the *tonneau, toise, quartier, parpaing,* or *carreaux* in the purchase of stone, but these refer to cubic measurements or sizes and shapes of stone. By measuring structures contemporary to St.-Maclou, such as the Tour de Columbier, the Hôtel du Four, the Grand Moulin, and the Palais de Justice, Raymond Quenedey has suggested that the unit of measure varied between .311m and .328m in fifteenth-century Rouen, with an average unit of measure equal to .324m.[73] Thus the *toise* was equal to 1.944m or six feet and the *perche* equal to 7.776m or twenty-four feet. In addition, the collection of the Musée des Antiquités in Rouen contains a folding bronze foot marked off to .324m, which has been identified by Quenedey as a sixteenth-century tool.

Since the geometry, setting-out procedure, written sources, and archaeological evidence suggest that construction began in the straight bays of the choir, one would expect to find a multiple of a foot there. Regardless of whether the dimensions are read from the outer wall (which, as I have shown, was the critical dimension in the layout of the building), the inner wall, or the center of the wall, none of the measurements for the overall width of the choir are divisible by the standard foot of .324m, .325m, or .295m.[74] Nor does one find a "foot" in the width of the central vessel. The transept module square suggested in Fig. 7 is close to a multiple of the foot (18.474m is less that a centimeter from fifty-seven feet, but this may be coincidental since a longer unit or "sajène," needed to lay out large dimensions, cannot be created from fifty-seven feet). The multiplication of a small unit such as .324m over a long distance does not seem practical. The geometric schemes and setting-out procedure, however, suggest that the builders needed to decide on only one direct measurement, the overall width of the transept. The subse-

[68] Murray and Addiss, 64–65.

[69] Prak, 209–212; J.R.H. James, *The Template-Makers of the Paris Basin,* Leura, Australia 1989, 70–76; and D. Walsh, "Measurement and Proportion at Bordesley Abbey," *Gesta,* XIX, 2, 1980, 113.

[70] W. Steinke, "The Flamboyant Gothic Church of Caudebec-en-Caux: A Neglected Masterpiece of French Medieval Architecture," Ph.D. diss., New York University, 1982, 74–82.

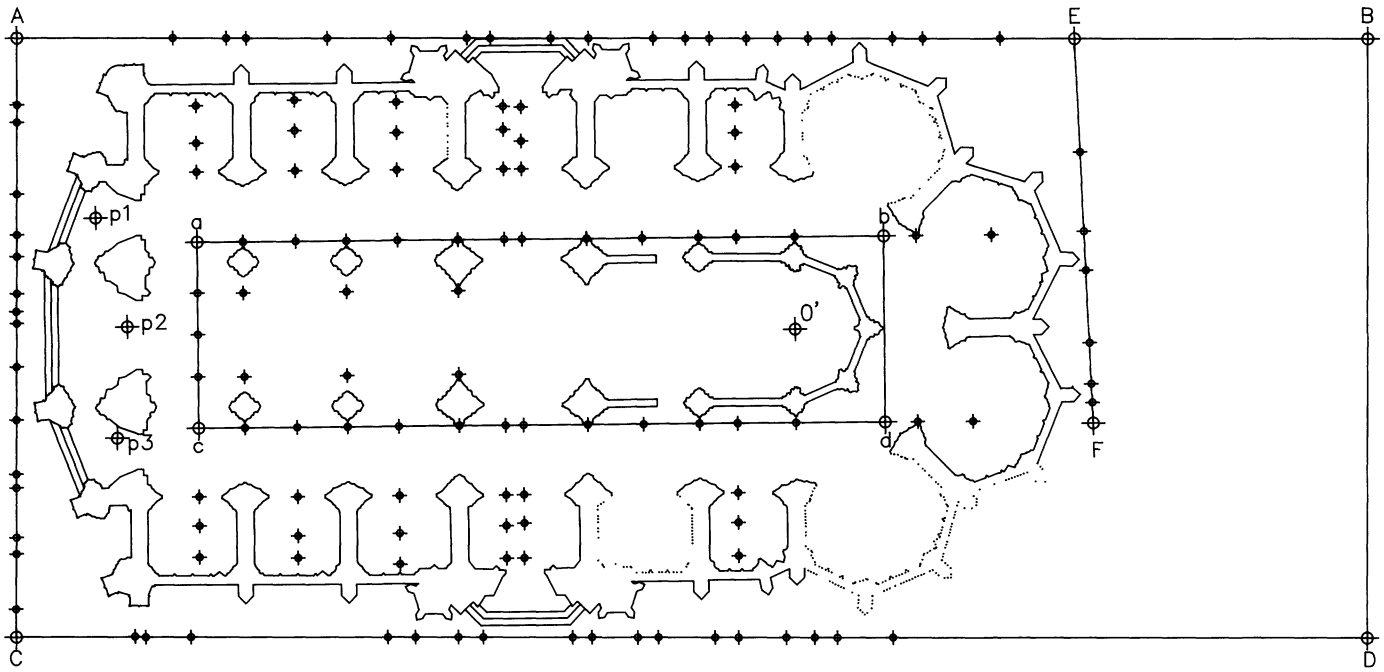
[71] For example, a contract of 1434 between William Wolston, squire, and Thomas Pecham, cleric representative for the Duke of York, and William Harwood, master mason for the construction of the nave of Fotheringhay Church, requested that the unit of measure be the English yard of three feet and that measurements were to be taken with the walls (D. Knoop and G.P. Jones, *The Medieval Mason,* Manchester, 1933, 220ff). Henry VI's "Will and Intent" dated March 12, 1448 also specifies the interior dimensions in feet for King's College Chapel; see R. Willis and J. Clark, *The Architectural History of the University of Cambridge,* I, Cambridge, 1886, 368–369.

[72] Beaurepaire (as in n. 13), 216–220.

[73] R. Quenedey, "Métrologie rouennaise. Instruments et mesures de longueur," *Bulletin philologique et historique du Comité des Travaux Historiques et Scientifiques,* 1920, 301–309.

[74] Width of Transept

from outer wall to outer wall	26.126 m
from inner wall to inner wall	25.242 m
from center of wall	25.648 m
Nearest Multiple of .324 foot:	80 feet (25.920 m)
	81 feet (26.244 m)
Width of Central Vessel:	
at transept to pier centers	7.617 m
using transept module	7.652 m
Nearest Multiple of .324 m foot:	23 feet (7.452 m)
	24 feet (7.776 m) *perche*
Transept Macro Module:	
Nearest Multiple of .324 m foot:	57 feet (18.468 m)



27 St.-Maclou, Rouen, plan, Survey Stations (drawing: H. Shih)

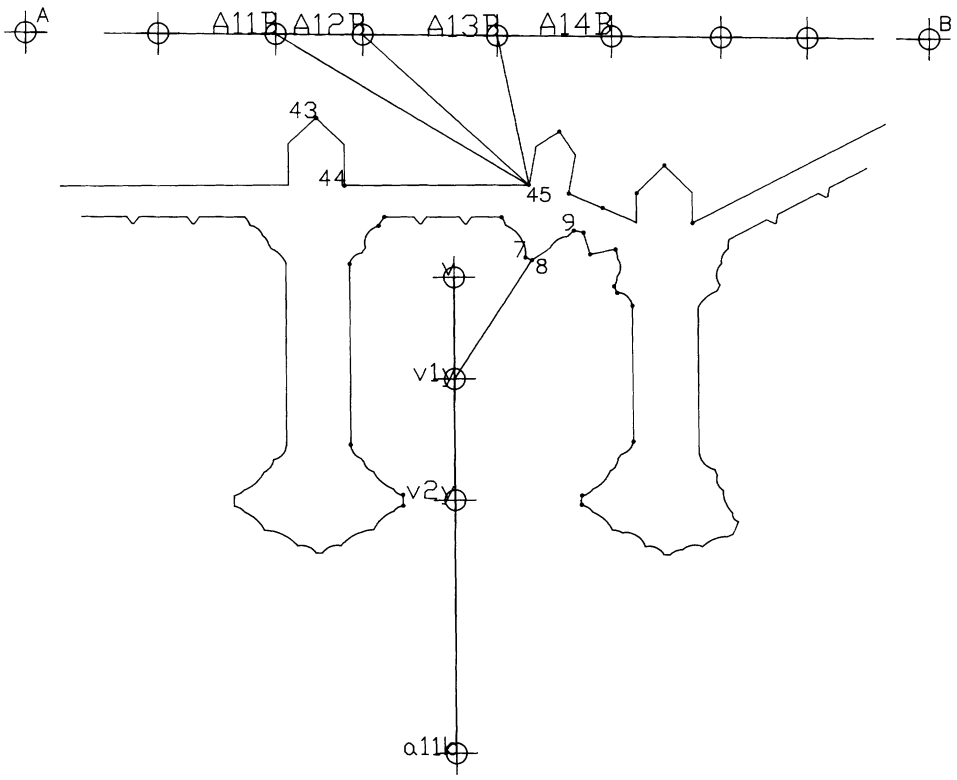
quent measurements were established through geometric constructions, and therefore the distances are incommensurable. One cannot expect to find a "foot" in any of the overall or larger dimensions of the church. It seems most likely that the initial measurement was determined by the space available on the site, or perhaps it was a measurement that was "symbolically" related to the old thirteenth-century church of St.-Maclou or even cathedrals of Rouen or Paris to which Pierre Robin owes much of his design.[75] The exact source of this unit may never be known, but the whole problem of the use of the foot in plan design must be reevaluated.

On the other hand, the use of a foot as a unit of measure is clearly evident in the design of details. The foot of .324m was the basis for the design of the west façade buttresses of St.-Maclou (see Fig. 15). Templates would have been used to convey the design from master to *appareilleur* and the smaller dimensions could more easily be controlled by the use of a unit of measure. Much work still has to be done in this area, and only detailed sections from many layers of the piers and buttresses may reveal the true proportional systems and standardized unit of measure.

The broader implications of the study of the plan of St.-Maclou may have to await comparable investigations. St.-Maclou may also be more of an exception than the rule in plan designs of the fifteenth century. Construction of Gothic buildings in any period was rarely unaffected over a long period of time, and few were constructed under the circumstances that allowed for the uniformity found at St.-Maclou. But perhaps it is time to reconsider some long-held notions concerning French Flamboyant architecture. Focillon's expressed view that Flamboyant architecture lacked clarity, innovation in structure, and represented the decline of Gothic style, is not confirmed by the study of the plan. His definition of architecture was based solely on superficial decorative patterns, which were indeed complex and exuberant. One cannot fail to notice the celebration of stone carving and technical accomplishment in structures such as the porch of Notre-Dame in Louviers or the central portal of Rouen Cathedral. The real innovation at St.-Maclou, however, and perhaps at many other fifteenth-century buildings is not limited to tracery patterns. Behind the intricate articulation and lush decoration lie a design system of elegant simplicity and a structural system of maximum efficiency. This reflects the great premium placed on economic and artisanal values by a new class of patrons and craftsmen. The plan design and hence the relationship of mass and space are based on a simple, unified, clear, and expedient geometry. In both plan design and structure, St.-Maclou represents a perfection, or, at the very least, a culmination of basic principles first expressed in the design of late twelfth- and thirteenth-century churches.

This is not to deny the complexity of forces at play on the development of architecture in the fifteenth century. Dramatically different social, economic, and political situations formed the background for the construction of churches. Surely the adoption of unorthodox plan features would not have been tolerated if they did not enhance or promote the activities that took place within or provide a powerful meaning for the patrons who funded the construction and ultimately approved of the design. But intangible mental patterns intimately linked the workshops of fifteenth-century Rouen with those of the thirteenth-century High Gothic cathedrals. These mental patterns reveal themselves most explicitly in the design process and provide criteria beyond

[75] Examples are numerous; see R. Krautheimer, "Introduction to an 'Iconography of Mediaeval Architecture,' " *Journal of the Warburg and Courtauld Institutes*, XIII, 1949, 1–33. Both Suger and Gervais refer to measurements taken from the old church. Davis (p. 132) suggests that the length and width of the new chevet of Altenberg were derived from the length of the 12th-century transept.



28 St.-Maclou, Rouen, plan, Chapel NIIEII (drawing: H. Shih and L. Neagley)

stylistic motifs for understanding Late Gothic architecture. Moreover, preliminary evidence suggests strong similarities between High Gothic and Late Gothic design procedures. Thus, certain Late Gothic features of St.-Maclou, such as the axial pier, that have been viewed as "international features" are more related to common design practices and to the priority given to the craft of masonry than to a vague notion of long-distance "influence." St.-Maclou is part of a design continuum of monumental Gothic architecture and participated in the continuing formal and technical evolution of northern French architecture. But what distinguishes St.-Maclou from the High Gothic is the freedom and willingness to expose the geometric underpinnings of the craft and to showcase the technical virtuosity and individuality of the craftsman.

The explicit purity of the underlying geometry at St.-Maclou is first and foremost a reflection of the artistic personality of Pierre Robin. Few Late Gothic churches can compare in harmony of style and refinement in proportion. What little we know of Robin suggests that he was a renowned draftsman; the pervasive intelligence of his design, the linear quality of his articulation, and the academic appeal of his style all go to support this characterization. Although many of his contemporaries were enticed by various details of his plan, none were able to integrate fully all aspects of plan, elevation, and massing into so elegant an expression of Late Gothic design.

Linda Neagley has published articles on Late Gothic architecture in the Journal of the Society of Architectural Historians *and the* Bulletin of the Detroit Institute of Arts, *and is currently completing the book* Disciplined Exuberance. Essays on the Parish Church of Saint-Maclou and Late Gothic Architecture in Rouen. *She is presently co-director of an NEH-funded plan survey project on St.-Urbain, Troyes, and St.-Ouen, Rouen [Department of Architecture, University of California, Berkeley, Calif. 94720].*

Appendix

Survey and Drafting Method

Great discrepancies exist in the accuracy of measurements and dimensions in modern plans of medieval monuments. For comparative studies in medieval plan design to be meaningful, scholars must take great care to apply uniform methods in the recovery and recording of dimensional data.[76] The 1988 St.-Maclou Survey Project, funded by the University of Michigan, was an attempt to capture the subtle idiosyncrasies and complexities of the medieval building by taking full advantage of current technology combining a digital planimetric survey with computer drafting.[77]

All the plans illustrated in the text are computer-generated (using an AutoCAD program of an Apollo 4000

[76] A good summary of the history of methods used in measuring historic monuments is provided by E. Fernie, "Historical Metrology and Architectural History," *Art History*, 1, 4, Dec. 1978, 383–399.

[77] I am indebted to Professor Ragendra Aggarwala of the University of Michigan Department of Civil Engineering, who directed the survey, and to three graduate students from the Department of the History of Art, Mayra Rodriguez, Rebecca Price-Wilkin, and Leslie Cavell, who assisted in the survey. The base plan was drafted by Heman Shih, a graduate student from the University of Michigan School of Architecture. Technical support was graciously provided by Matthew Barritt, Director of the Advanced Workstation Laboratory of the University of Michigan.

There were sections of the inner and outer walls that were not accessible (the chapel of Ste. Clotilde, SIIAII, for example, was destroyed in 1944 and portions of the first northern radiating chapel, NIIAII, were covered with wooden paneling). These walls could not be measured directly and are therefore indicated in Fig. 28 by dotted lines.

Field Notebook
July 28, 1988

Exterior, North Side
Angle Observations from Stations on AB line

00° > North

From	To	Angle
A14B	43	164° 17′ 53″
A14B	44	150° 31′ 44″
etc		
A13B	43	155° 20′ 52″
A13B	44	135° 17′ 56″
A13B	45	77° 35′ 59″
etc.		
A12B	43	119° 11′ 57″
A12B	44	96° 41′ 44″
A12B	45	41° 42′ 16″
etc		

Calculation Notebook
Calculations for Exterior Points 43, 44, and 45*

00° > North

From-To	Angle				Mean Length
	Point 43				
A14B-43	164° 17′ 53″	15° 42′ 07″			
A13B-43	155° 20′ 52″	24° 39′ 08″			
A12B-43	119° 11′ 57″	60° 48′ 03″	(A14B-A11B) 1.3337	(A13B-A11B) 1 3343	1 3340
	Point 44				
A14B-44	150° 31′ 44″	29° 28′ 16″			
A13B-44	135° 17′ 56″	44° 42′ 04″	(A14B-A12B) 2 1876	(A13B-A12B) 2 1879	2.1878
A12B-44	96° 41′ 44″				
	Point 45				
A13B-45	77° 35′ 57″	102° 24′ 03″	(A13B-A11B) 2 2029	(A13B-A12B) 2.2022	2 2026
A12B-45	41° 42′ 16″				
A11B-45	30° 22′ 25″	138° 17′ 44″			

*The distance from the survey station point to a point on the masonry is determined by solving a triangle where two angles are known At least two triangles were solved for every point and the mean distance was used

Calculations for Coordinates of Exterior Points

From	To	Angle	Mean Length	Bearing**
A11B	43	63° 53′ 36″	1 3340	25° 32′ 32″
A12B	44	96° 41′ 44″	2 1878	7° 15′ 36″
A13B	45	102° 24′ 03″	2 2026	11° 50′ 11″

Latitude		Departure		Balanced		Coordinates***	
N+	S−	N+	S−	Latitude	Departure	Y (Northing)	X (Easting)
−1 2036		+0 5752		S 1 2036	E 0 5752	39.1832	56 3101
−2 1703		−0.2765		S 2 1703	W 0 2765	38 2041	56.7156
−2 1558		+0 4518		S 2 1558	E 0.4518	38 1995	59 3845

**Interior and Exterior rectangles (ABCD and abcd) were connected at point A4C at an angle of 0° 33′ 52″ Corrections in the bearings along the exterior rectangle had to be made through calculation

***Coordinates for 43, 44, and 45, were based on coordinates for A11B (40 3868, 55 7349), A12B (40 3744, 56 9921), and A13B (40 3553, 58.9327) respectively

29 Field Notebook: Observations and calculations for points 43, 44, 45, exterior wall of chapel NIIEII

Field Notebook
July 26, 1988

Interior, Chapel NIIEII
Angle Observations and Linear Measurements
Coordinate Calculations

00° > South

From	To	Length	Mean	Angle	Azimuth	Bearing	Cos	Sin
7	vij	2.0335 2.0358	2.0347	210° 34' 25"	30° 34' 25"	N 30° 34' 25" E	.8610	.5086
8	vij	2.0490 2.0478	2.0484	213° 24' 05"	33° 24' 05"	N 33° 24' 05" E	.8348	.5505
9	vij	2.7510 2.7535	2.7523	218° 58' 35"	38° 58' 35"	N 38° 58' 35" E	.7774	.6290

From	To	Latitude N+	Latitude S-	Departure E+	Departure W-	Balanced Latitude	Balanced Departure	Coordinates* Y (Northing)	Coordinates* X (Easting)
7	vij	+ 1.7519		+ 1.0348		N 1.7519	E 1.0348	37.157	59.329
8	vij	+ 1.7100		+ 1.1276		N 1.7100	E 1.1276	37.115	59.422
9	vij	+ 2.1396		+ 1.7312		N 2.1396	E 1.7312	37.545	60.025

*Coordinates for vij = 35.405, 58.294

30 Field Notebook: Observations and calculations for points 7, 8, 9, interior wall of chapel NIIEII

computer) and represent a cross-section of the church at the interior floor level. The plan records the irregularities of construction, such as they are, while the design schemes that are overlaid in the illustrations are perfectly constructed geometric forms. No attempt has been made to regularize the plan to fit the ideal geometries. The close correspondence between the irregular masonry of the plan and the design schemes evident in the illustrations underscores the remarkable precision of the fifteenth-century construction.

In order to avoid any assumptions about the layout of the building, the alignment of walls, piers, buttresses, etc., or the underlying geometric schemes, points were identified along the interior and exterior walls of the church at every break in direction or juncture of masonry. The coordinates of these points were determined with reference to a common rectangular grid set out on both the interior and exterior of the monument. This survey control framework was first established with the highest possible precision (1:30,000) using precise survey instruments to measure angles and distances (Fig. 27). Using the primary framework, additional secondary control stations were established for detailed observation of individual parts of the building. Points marked on the walls, piers, buttresses, and portals of the building were observed from several stations and located using methods of triangulation or radiation as appropriate. Suitable checks were provided to control error propagation and facilitate adjustments. These coordinates were entered into AutoCAD and formed the basis for drafting the plan of the building.

The survey method used is described in any survey textbook, and involved the use of two Wild-2 theodolites, an EDM instrument, a 30-meter Lufkin steel tape, a 50-meter Minvar Lufkin tape, and an assortment of tension handles, clamps, markers, taping pins, smaller tapes, and Field Survey Books.[78]

Because an extensive amount of data was to be collected and entered into the Field Survey Books, the Hamman-MacLean number system was chosen to provide a precise nomenclature for the masonry and enclosed spaces (Fig. 2).

Figs. 28–30 indicate the typical identification of points and calculation of coordinates for establishing the wall in the choir chapel NIIEII. Survey stations were chosen along line *AB*, for example, that provided clear siting to buttresses, staircases, etc. From survey station *A11B*, angles were read (to the nearest second) using the theodolite for points 38 through 45. For the next station, *A12B*, angles to points 39 through 45 were recorded, and from *A13B* , angles to points 41 through 49 were recorded, and so on.

On the interior of the same chapel, a grid of station lines was created by constructed survey stations along lines perpendicular to the interior rectangle that extended into each chapel. From stations along the rectangle and grid, angles were read to points on the wall and piers and distances were measured. Linear measurements were recorded to the nearest one tenth of a millimeter and were taken at least twice by different teams. Variations of five tenths of a millimeter were tolerated and mean distances were used in the calculations.

The coordinates were then drafted on the computer using an AutoCAD program and the final drawings were plotted on a Hewlett Packer Plotter. The computer provides a great deal of flexibility in scale, size, and color, as well as an analytic power not possible with hand-drafted drawings. Accurate dimensions can be retrieved from the computer that would not be possible from drawn plans. Geometric forms can be easily moved and rotated to reveal relationships. For instance, the transept geometry expressed in Fig. 8, once constructed, was snapped onto nodes in the center of the hemicycle *O'* and the center of the nave *O2* to reveal striking relationships.

[78] Procedures and calculation formulae are available in any surveying textbook: for example, R.C. Brinker and P.R. Wolf, *Elementary Surveying*, 7th ed., New York, 1984.

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